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Runnins River Watershed Stormwater Management Study

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6. AUTHOR(S)
John Kedzierski
Scott Acone
Ulrike Volz

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254-9149

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This study has been conducted under the Corps of Engineers' Section 22, Planning Assistance to States Program. The purpose of this investigation is to define the Runnins River Watershed and evaluate and document the quantity and quality of stormwater surface runoff into the river through watershed modeling of hydraulic conditions.

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Executive Summary

The Corps of Engineers was requested by the Rhode Island Department of Administration, Division of Planning to conduct a stormwater management study of the Runnins River watershed in East Providence, Rhode Island. The City of East Providence initiated the request and is also the cost sharing partner for this study. This study was conducted under the authority contained in the Corps of Engineers' Section 22, Planning Assistance to States Program. The focus of this study is on the issues, problems and potential solutions relevant to stormwater quality within the East Providence portion of the Runnnins River watershed.

The purpose of this investigation is to define the Runnins River watershed and evaluate and document the quantity and quality of stormwater surface runoff into the river through watershed modeling of hydraulic conditions. This included an analysis and review of existing water quality data, an analysis and inventory of existing development and land use contributing to possible water quality degradation, and, identifying and outlining possible solutions to be implemented within the watershed to help alleviate stormwater surface runoff quantity and quality problems. The framework for a comprehensive stormwater management strategy and a pollutant loading analysis have also been provided.

The Runnins River watershed covers approximately 9.87 square miles within the City of East Providence, Rhode Island (pop. 50,380), and the towns of Seekonk, and Rehoboth, Massachusetts. East Providence comprises 23% of the watershed, Seekonk 70%, and Rehoboth 7%. The watershed is also part of the larger Narragansett Bay watershed. About 2.3 square miles of the eastern portion of East Providence is within the watershed which accounts for approximately 17% of the land area within the City and almost 10% of the City's population.

Problems and issues concerning the Runnins River include encroachment along the river and its tributaries, destruction and filling of wetlands, development occurring within the floodplain or poorly drained areas, potential failure of individual sewage disposal systems, and an increase in impervious surfaces.

This report describes the watershed's land use and provides a hydrologic analysis and water quality assessment. The hydrologic analysis considers the entire drainage area of the

Runnins River, focusing on East Providence. The analysis presents information on climatology, streamflow characteristics, and potential impacts of future development. The hydrologic analysis is contained in Appendix B. The water quality assessment reviewed water quality data which has been collected from Rhode Island and Massachusetts. This includes data collected by the Pokanoket Watershed Alliance, a citizen water quality monitoring group. The water quality assessment is contained in Appendix C.

The conclusions and findings of this investigation are summarized below.

o Although potential sources of fecal coliform contamination which could possibly originate in East Providence have been qualitatively identified, it is unlikely that East Providence is a significant contributor of the fecal coliform contamination found in the Runnins River.

o Although fecal coliform contamination has been identified as a significant pollutant within the Runnins River, existing data is inconclusive for determining either specific nonpoint sources of contamination or to apportion fecal coliform concentrations to either East Providence or Seekonk.

o Because wet weather sampling has not yet been accomplished, stormwater runoff originating in East Providence has not been characterized based on pollutant type or concentration. This is required before specific stormwater control strategies can be adopted. Sampling and monitoring of various wet weather events should be accomplished to identify other pollutants (e.g., metals, suspended solids) and their potential sources. Monitoring and inspection of outfalls can also definitively eliminate any potential sources of fecal coliform in East Providence. The National Pollutant Discharge Elimination System (NPDES) permitting process also requires stormwater sampling and monitoring.

o Water quality degradation of the Runnins River has been previously documented and is an ongoing concern to the citizens of the watershed and downstream receiving waters such as Hundred Acre Cove. However, the source of these pollutants has not been completely identified. There are 7 storm drains from East Providence and 11 from Seekonk discharging to the Runnins River, and about 30 storm drains discharging to the Hundred Acre Cove area from Barrington. Therefore, based on the information derived in this report, it appears that East Providence is not a primary contributor of fecal coliform

contamination in the Runnins River. The pollutant contribution from the Barrington storm drains and the effects of tidal flushing and currents on pollutant transport and dispersion patterns within Hundred Acre Cove have not yet been determined.

Based on the results of the hydrologic modeling process, the water quality assessment, and information contained in previous studies, various recommendations have been identified. A summary of these recommendations follows.

- **Runnins River Watershed Management District**

East Providence should provide a method of commitment for coordinating and establishing sound stormwater management practices throughout the Runnins River watershed. One possible means of accomplishing this is through the establishment of the Runnins River Watershed Management District. This concept is to provide enhanced coordination and cooperation at the local level while dealing with issues such as urbanization and development and protecting the natural resources and water quality of the Runnins River.

- **Stormwater Utility**

The City should explore various funding mechanisms as a means of financing a comprehensive stormwater management program. One possible financing method is a stormwater utility to fund a city-wide stormwater management program and the possible NPDES permit requirements.

- **NPDES**

The City should plan for the possibility of having to develop the data and information which is necessary for the NPDES permit application. A gross cost estimate for this permit application process is about $100,000 for the City of East Providence.

- **Erosion & Sediment Control**

Adopt and implement the Rhode Island Soil Erosion & Sediment Control Act and use the <u>Rhode Island Soil Erosion and Sediment Control Handbook</u> as guidance for installing and maintaining proper erosion and sediment control techniques at construction sites.

o **Zoning Ordinances & Land Use Restrictions**

The City of East Providence should update present zoning configurations in regard to the goals and objectives of a stormwater management program.

o **Deicing/Snow Removal Management**

The City should review its use and storage of deicing chemicals and salt in relation to overall stormwater management goals. In particular, any storage piles in the vicinity of the river or its tributaries should be properly covered.

o **Inspecting & Identifying Storm Drain Systems for Non-Stormwater Entries**

The City should develop and implement a program to periodically inspect outfalls and identify non-stormwater entries to the City's storm drain system.

o **Infiltration & Storage Methods**

Infiltration and storage methods require site-specific analysis and knowledge of pollutant types and loads before implementation. Although they are capable of providing significant pollutant removal efficiencies, the type and concentration of the pollutants must first be identified through wet weather sampling. Factors such as slope, geology, and local groundwater conditions must also be considered and examined.

o **Stormwater Management Program**

The framework and essential elements of a comprehensive stormwater management program, as well as characteristics of a successful stormwater management program are provided within the main text of the report.

The City of East Providence should first formulate its stormwater goals and objectives for the Runnins River watershed and other portions of the city. Goals should be consistent with those established for Narragansett Bay and should account for the possibility of applying for a NPDES permit. Through cooperation and coordination with neighboring communities

such as Seekonk, Massachusetts, the City of East Providence can then develop a Runnins River watershed stormwater management program which meets its goals and objectives.

To aid in formulating these goals and objectives, certain preliminary tasks have been identified. These tasks can provide the basis to develop a comprehensive stormwater management program, help determine the need for a stormwater utility as part of the program, and provide immediate benefits of increased public visibility of the City's stormwater management efforts. As part of the process of developing and funding a comprehensive stormwater management program and/or stormwater utility, the City should undertake a public education and awareness program concerning stormwater issues throughout the City. One method to gain awareness and public support is to perform tasks which are both highly visible to the general public or which provide immediate benefits. These tasks will also aid in complying with the NPDES permit requirements. The tasks include:

1. Survey local residents and businesses concerning flooding and water quality problems throughout the city and create an inventory of specific problem sites;

2. Inspect storm drain outfalls for dry weather flow and inspect individual sewage disposal systems to ensure their proper operation;

3. Create an inventory of storm drainage features (e.g., outfalls, catchbasins, manholes, culverts, etc.), and establish and implement a regular catchbasin cleaning program to reduce sediments and debris within the storm drain system;

4. Implement a wet weather sampling program to characterize the type and concentration of stormwater pollutants originating from the East Providence portion of the watershed.

5. Identify potential sources of typical nonpoint pollutants by investigating current land uses in each of the various subwatersheds and outfall catchment areas;

6. Rank those sources of runoff which are likely contributors to water quality problems and develop and implement a monitoring plan to characterize pollutants from these sites and within the tributaries;

7. Identify appropriate sites and develop a program to implement possible stormwater control measures for these sites.

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I. INTRODUCTION

1. Study Background

The Corps of Engineers was requested by the Rhode Island Department of Administration, Division of Planning to conduct a stormwater management study of the Runnins River watershed in East Providence, Rhode Island. Although the watershed extends over State boundaries into Massachusetts, the focus of this study is on the issues, problems and potential solutions relevant to stormwater quality within the City of East Providence. However, since watersheds and their related problems such as flooding and water quality issues are not confined by jurisdictional boundaries, portions of the watershed outside of East Providence have been included within the scope of the analysis.

There has already been a large amount of public involvement concerning issues within this watershed. For example, the Pokanoket Watershed Alliance has been conducting regular water quality sampling of the river since June, 1992. There has also been involvement by other agencies and parties including the Massachusetts Department of Environmental Protection (MADEP), the National Park Service (NPS), the New England Interstate Water Pollution Control Commission (NEIWPCC), the Rhode Island Department of Environmental Management (RIDEM), the Massachusetts Riverways Program (an agency of the Department of Fisheries, Wildlife & Environmental Law Enforcement), and the Mobil Oil Corporation.

2. Study Authority

The Corps of Engineers, at the request of the Rhode Island Department of Administration, Division of Planning, has conducted a stormwater management study of the Runnins River watershed in East Providence, Rhode Island under the authority contained in the Section 22, Planning Assistance to States Program. The City of East Providence initiated the request and is the cost sharing partner for this investigation which has been coordinated with its Department of Planning and Urban Development.

3. Study Purpose and Scope

The purpose of this investigation is to define the Runnins River watershed and evaluate and document the quantity and quality of stormwater surface runoff into the river

through watershed modeling of hydraulic conditions. The Scope of Services is included as Appendix E. In accordance with the Scope of Services, the following tasks have been accomplished: analyze and review existing water quality data; analyze and inventory existing development and land use contributing to the water quality degradation; and, identify and outline possible solutions which could be implemented within the watershed to help alleviate stormwater surface runoff quantity and quality problems. The framework for a comprehensive stormwater management strategy has also been developed for the watershed.

The scope of this study was limited to existing information and ongoing data collection efforts which were available from Federal, State, Municipal and other sources. Ongoing data collection efforts include continued attempts at wet weather water quality sampling by the New England Interstate Water Pollution Control Commission and ongoing dry weather water quality sampling by the Pokanoket Watershed Alliance. There has been no wet weather sampling to date. This study focused on identifying problems and formulating solutions for the portion of the watershed within the City of East Providence. Areas of additional study have also been identified.

4. Data Provided by City of East Providence

The City of East Providence supplied existing land use and zoning data and other pertinent information to aid in the development and documentation of the quantity and quality of stormwater surface runoff into the river.

5. Other Pertinent Studies

1) The Hidden River - A Land Use & Environmental Study For The Runnins River Watershed; Feather, D., et.al.; University of Rhode Island; 1989.

2) East Providence Comprehensive Plan; Prepared for the City of East Providence by BRW, Inc.; 1992.

3) Sewer System Infiltration/Inflow Study and SSES Analysis; Prepared for the City of East Providence by Hayden/Wegman; August 1988.

4) Comprehensive Site Assessment Work Plan - East Providence Terminal; Volumes I and II; Prepared for Mobil Oil Corporation by Roux Associates; December 1993.

II. PROBLEM IDENTIFICATION

The problems associated with the Runnins River watershed have been previously documented in the Hidden River report and the East Providence Comprehensive Plan.

According to The Hidden River - A Land Use & Environmental Study For The Runnins River Watershed there are a number of issues concerning the Runnins River. These include: buffer encroachment along the river and its tributaries; destruction and filling of wetlands within the watershed; development occurring within the floodplain; potential failure of individual sewage disposal systems, particularly in Seekonk; development in areas of poorly drained soils; and an increase in impervious surfaces due to development. The East Providence Comprehensive Plan also cites the effects of encroachment and urban development on the Runnins River watershed as major concerns. The plan states that the "primary threats to the Runnins River and other wetlands in East Providence are pollution and intrusion."

There are several problems associated with the watershed area. Soils in several areas are generally considered undesirable for development (e.g., increased imperviousness and the use of septic systems) because of poor drainage characteristics and the effects of erosion on the river. Furthermore, the soils of the surrounding wetlands are characterized by hydric soils, which are soils capable of storing flood waters and are not suitable for structures. Therefore, if development were to occur at these locations, the infiltration capacity of these soils would be lost. In an area characterized by major retail and strip commercial facilities and light industry, there are large areas of impervious cover which increase stormwater runoff, damage wetlands and reduce floodplain capacity. There are also a number of landfill sites within the watershed which may be contributing to the overall water quality degradation. These sites are described in the next section.

According to the East Providence Comprehensive Plan, the Runnins River watershed has been identified as an area of critical concern and two critical issues have been identified. The first critical issue consists of drainage and stormwater pollution caused by the effects of encroaching urban development and possible septic system failure within Seekonk. Pollution resulting from septic tanks may be the result of inadequate maintenance of the individual sewage disposal system. Another potential problem is that the soil around the leaching fields is not permeable enough to accept wastewater. This condition may also result in surface

ponding of wastewater which may runoff and enter a local water body or storm drain system resulting in stormwater pollution problems. The Runnins River and its associated wetlands with a terminus in Hundred Acre Cove comprises one of the largest saltmarsh ecosystems in Rhode Island. The greatest threats to this natural resource are pollution and intrusion. Human encroachment from businesses and residences increases the potential for degradation by generating urban runoff, increasing stormwater runoff, and potentially increasing sedimentation in streams and contamination from chemicals such as fertilizers, pesticides, and road salts. Because of development, there is also the potential for soil contamination by chemical agents, petroleum products, or other contaminants. This has already occurred at the Mobil facility where petroleum hydrocarbons have infiltrated the groundwater.

The second critical issue is that the Runnins River and its resources are not very visible or accessible to the public. According to the "Hidden River" report, "...The Runnins River suffers from an identity crisis...". A large portion of the general public does not know of its origins in Massachusetts or its capacity as a state boundary. This is due in part to an absence of public access and rights-of-way which offer only a limited view of overgrown areas and culverts. These crossings include School and Mink Streets and the Luthers Corners area. The river is navigable by canoe at these crossings, however, it is difficult to gain access at these points. Physical access is also limited by the lack of any defined trail system running parallel to the river. Due to minimal access, recreational use of the Runnins River is limited.

There are also concerns about the habitats of various plants and animal species in the watershed. The existence of the Northern Leopard Frog and the Black Terrapin Turtle are threatened by the intrusion of development and urbanization. Runoff and encroachment from urban development promote the degradation of water quality and the loss of habitat for various mammals and waterfowl that thrive in the area and adjacent wetlands. Urban runoff sedimentation and contaminants pose threats to East Providence's river system and wildlife habitats.

The Runnins River watershed is also suspected of being a nonpoint pollution source to Hundred Acre Cove in Barrington. In particular, it is perceived that the Runnins River contributes elevated levels of fecal coliform which may be responsible for the closure of shellfish beds in Hundred Acre Cove. However, all potential sources of fecal coliform to Hundred Acre Cove have not been investigated, including an estimated 30 storm drains discharging into the vicinity of the cove from the Barrington area.

III. EXISTING CONDITIONS

1. Watershed Description

The Runnins River watershed covers approximately 9.87 square miles (6,317 acres) within the City of East Providence, Rhode Island (pop. 50,380), and the towns of Seekonk and Rehoboth, Massachusetts. See Figure 1. The City of East Providence is bordered by the Providence and Seekonk Rivers to the west, the City of Pawtucket to the north, the Town of Barrington to the south, and the Town of Seekonk, Massachusetts to the east. The headwaters of the Runnins River watershed are in Rehoboth, however, the actual river begins in Seekonk and flows generally southwesterly through Seekonk. Portions of the Runnins River form the state boundary between East Providence, Rhode Island and Seekonk, Massachusetts flowing in a southerly and southeasterly direction to the Mobil dam. Downstream of the Mobil dam, the Runnins becomes the Barrington River, then merges with the Palmer River to become the Warren River which eventually discharges into Narragansett Bay.

The upper watershed of the Runnins River is relatively undeveloped with some residential and agricultural areas, and numerous wetlands and forested area. A United States Geological Survey (USGS) staff gage located at Pleasant Street in Seekonk measured annual peak stages and flows from 1967 to 1983. Upstream of this gage, the average slope of the river is about 11 feet per mile for its 4.2 mile length. About one-quarter of the watershed area provides storage of runoff during rainfall events, either in wetlands or lakes and ponds. Downstream of the gage to the Mobil dam, the watershed changes character. East Providence, on the western border, is a mature, urbanized area. Seekonk, on the eastern side is rapidly developing, with increasing impervious areas and runoff rates. Although there is substantial storage provided just downstream of Pleasant Street by a large wetland area, there is little other storage provided through this reach. The average slope of the river through this reach changes to about 13 feet per mile for 3 miles.

For this study, the downstream limit of the Runnins River is assumed to be the Mobil dam. This dam was built in the 1920's by the Mobil Corporation to divert water to a pump house for industrial use at the Mobil facility. The dam consists of a small earthen berm with an overflow section consisting of a concrete wall about 85 feet long and 2 feet wide. The spillway crest is estimated to be 4.5 feet NGVD (National Geodetic Vertical Datum). It

appears that during normal tide ranges, the dam is the upstream limit of tidal influence, however, during storm tides above the spillway crest, the tidal influence can be expected as far upstream as Highland Avenue. The slope of the river downstream of the Mobil dam is very flat and the flow is influenced by the tides.

There are three small tributaries to the Runnins River which originate in East Providence. (See Plate 13 - Appendix B). The northernmost tributary starts near Waterman Avenue and drains the area around East Providence High School and the industrial areas on Commercial Way. This tributary flows through wetlands before entering the Runnins River in Seekonk. The total drainage area of this tributary is 1.08 square miles. A second tributary drains the Armington Corner/Kent Heights section of East Providence. This tributary is commonly referred to as Orange Juice Creek. It drains the former Kent Heights landfill and the industrial area around Amaral Street. It's total drainage area is about 0.59 square mile. The third tributary begins at the Gate of Heaven Cemetery and flows adjacent to a gravel pit before discharging into the Runnins River. The cemetery tributary drains approximately 0.18 square mile and also includes portions of the Amaral Street industrial area.

The total land area of the City of East Providence is about 13.7 square miles of which the Runnins River watershed covers about 2.3 square miles (1,472 acres) comprising the eastern part of the city. Therefore, the watershed accounts for approximately 17% of the land area within the city. The watershed also covers the central portion of the Town of Seekonk covering approximately 6.9 square miles (4,416 acres), and about 0.7 square mile (448 acres) encompassing the western portion of the Town of Rehoboth.

East Providence comprises about 23% of the watershed, Seekonk 70%, and Rehoboth 7%. The river's overall length is about 7.5 miles originating from an extensive wetlands system near Walnut and Prospect Streets in the Town of Seekonk and flowing to the East Providence-Barrington, Rhode Island boundary. This is where the Runnins River empties into the Barrington River and Hundred Acre Cove. Figure 1 shows the watershed and municipal boundaries.

2. Land Use

Land uses for the watershed within East Providence, Seekonk, and Rehoboth were identified from information contained in the East Providence Comprehensive Plan, the "Hidden River" report, the Town of Seekonk's Master Plan, aerial photos provided by the Rhode Island Department of Administration, Division of Planning, and field observations.

A. East Providence Land Use

According to the "Hidden River" report which utilized aerial photographs, the watershed area was predominantly agricultural in the early 1950's. There were also large heavily forested areas. Other notable features included the Mobil refinery, sand and gravel extraction areas, the East Providence High School, and some commercial/industrial areas at the intersection of Route 6 and Fall River Avenue in Seekonk. Interstate 195 (I-195) and improvements to the Wampanoag Trail during the late 1960's and early 1970's resulted in economic growth and intensified development pressures within the watershed. Figure 2 shows generalized land use within the East Providence portion of the Runnins River watershed. The present division of land use within the City of East Providence is shown in Table 1.

TABLE 1
GENERAL EAST PROVIDENCE LAND USE
(Acres)

Type of Land Use	Total Area of City	Area Within Watershed	% Within Watershed
Vacant	524	191	34.9%
Residential	3,790	330	8.7%
Industrial	1,690	548	32.4%
Commercial	540	72	13.3%
Parks/Open Space	1,796	232	12.9%
Public/Semi-Public	430	99	23.0%
Total	8,770	1,472	16.8%

(1) Source of Total Area: East Providence Comprehensive Plan, 1992.

As shown in Table 1, one-third of the industrial land use within the city is located within the Runnins River watershed. Over one-third of the available vacant space within the city is also located within the watershed, with less than ten percent of the city's residential land usage occurring in the watershed. Between twelve and twenty-three percent of the city's commercial, parks, and public land usage occurs within the watershed. Because over one-third of the city's vacant land is contained within the Runnins River watershed, special considerations should be emphasized to manage this resource. Encroachment or urbanization of these lands without evaluating the impacts could further degrade water quality within the watershed.

Table 2 below and Figure 2 illustrate typical East Providence land use within the Runnins River watershed.

TABLE 2
EAST PROVIDENCE WATERSHED LAND USE

Type of Land Use	Area Within Watershed (acres)	Percent of Total w/in Watershed
Vacant	191	13.0%
Residential	330	22.4%
Industrial	1,548	37.2%
Commercial	72	4.9%
Parks/Open Space	232	15.8%
Public/Semi-Public	99	6.7%
Total	1,472	100.0%

Within the watershed, industrial land use is the most prevalent type, accounting for over one-third of the total. Residential is the next most frequently occurring land use type, accounting for over one-fifth of the total. Parks and open space account for about sixteen percent of the total while commercial, public lands, and vacant space make up the remaining twenty-five percent. Below is an analysis and projection of future land use patterns within the watershed.

i. Vacant Land Use:

Vacant lands currently account for almost 200 acres or 13% of the watershed area in East Providence. These lands, particularly those adjacent to the river, should be regarded as a valuable resource offering a buffer against urban encroachment and as possible points of public access to the river. The State of Rhode Island presently requires a fifty foot buffer around wetlands. Streams with a channel width of less than ten feet require a one hundred foot buffer, and streams over ten feet wide require a two hundred foot buffer. One of the larger vacant land tracts is in the southern portion of the watershed east of the Wampanoag Trail. This area is presently owned by the Mobil Oil Company and is zoned as industrial. However, this is also the site of the Mobil Runnins River Separator which is currently being capped in place. This area is subject to an easement in perpetuity to the State of Rhode Island to ensure that the site will remain undisturbed. However, in general, the urbanization of other vacant parcels within the watershed could lead to changes in local drainage patterns, increased imperviousness, and nonpoint sources of pollution from vehicular traffic and the specific industrial or commercial establishments which could use a site. Therefore, development of vacant lands should be carefully monitored for land use modifications which could lead to either increased flooding or water quality degradation.

Table 3 below is derived from information contained in the Comprehensive Plan and field observations. The vacant land in the watershed is currently zoned as follows:

TABLE 3
ZONING OF EAST PROVIDENCE VACANT LAND IN THE RUNNINS RIVER WATERSHED

Land Use	Approximate Number of Vacant Acres	Approximate Number of Acres Suitable For Development
Industrial	120 acres	20
Commercial	10 acres	10
Residential	30 acres	10
Open-Space	40 acres	30
Total	200 acres	70

As shown in the above table not all of the vacant land is suitable for development. The number of acres suitable for development was derived primarily from information contained in the Comprehensive Plan. According to the Comprehensive Plan, some of the vacant land is subject to flooding or has topographic constraints such as steep slopes. This limits the number of acres suitable for development. At present, of the available vacant land, only about 15% is suitable for future urbanization and development with industrial or commercial land uses. Land adjacent to the Runnins River should be rezoned as open-space or require developers to provide appropriate stormwater management techniques to ensure water quality protection. Another 20% of the vacant land suitable for development is zoned as Residential or Open-space. This is located near the former Kent Heights landfill. The remaining 65% considered to be unsuitable for development due to the constraints given above.

This analysis has been based on information contained in the East Providence Comprehensive Plan. There may be other factors such as physical topography or regulatory constraints which may enhance or prohibit future development of a particular site. This was not investigated in this study.

ii. Residential Land Use & Watershed Population:

The Runnins River watershed encompasses portions of four census tracts (103, 105.01, 105.02, and 107.01). These census tracts, and their neighborhood names are consistent with those found in the East Providence Comprehensive Plan. Census tract 103 is found within the Center City neighborhood and contains "...a substantial amount of single-,two- and three-family homes..." although "...it is more readily recognized for strip commercial, major retail facilities, light industrial, elderly housing and high-tech business...". The southeastern portion of this tract is within the Runnins River watershed.

The majority of census tract 105.01 lies within the watershed. The western half of census tract 105.01 (west of the Wampanoag Trail and south of I-195) is the Kent Heights neighborhood. This is primarily an older residential neighborhood with numerous apartment complexes. Commercial activity is limited to the northern part of this census tract along Route I-195. The eastern part is composed of industrial uses and also contains the old Kent Heights Landfill which was closed in 1969. This specific site is described in further detail in section "4. Landfills & Other Considerations".

Census tract 105.02 is the Mobil Property neighborhood. There are no residential land use areas within the watershed in this census tract. Therefore, it was assumed that the population within the watershed is zero for this census tract. The majority of this tract is owned by the Mobil Oil Company and contains its gasoline storage facilities. The Mobil facility consists of about 800 acres of which only about 170 acres are actually within the Runnins River watershed. However, much of the 170 acres is actually undeveloped and vegetated. There are also some areas of wetlands, forests, and a portion of the South Operations Area which is not vegetated just west of the Wampanoag Trail. Portions of three major areas of the Mobil facility lie within the watershed. They are the North Operations Area, South Operations Area, and the Runnins River Area. Each of these areas is briefly described below.

The North Operations Area extends from Route 114 south to an access road running east to west through the facility. The portion of the watershed in the North Operations Area contains an asphalt lake, a former asphalt lake, seven storage tanks, a swamp, and a spray basin. It also formerly contained sixteen other storage tanks of varying sizes which have since been removed. They contained fuel oil, kerosene, leaded and unleaded gas, and other petroleum products.

The South Operations Area within the watershed extends south from the access road boundary with the North Operations Area to the leased asphalt facility. It contained over 30 storage tanks of various sizes and a main oil-water separator. According to information in the <u>Comprehensive Site Assessment Work Plan</u> (Roux Assoc., 1993) it presently contains four small storage tanks, a boiler shop and an asphalt lake.

The Runnins River Area is located between the Wampanoag Trail (Rte. 114) and the Runnins River. It contains a former separator, an auxiliary separator, and a salt water pump house. The separators are presently being capped to prevent leachate contamination.

Historic hydrocarbon releases and spills, and ongoing remediation efforts are more fully described in part "5. Landfills & Other Considerations".

Census tract 107.01 is part of the Riverside neighborhood. However, only a small portion of the watershed extends into the northern section of this tract. The area located east

of the Wampanoag Trail (Route 114) is owned by Mobil and is the largest single undeveloped site in the city. It is also directly adjacent to the Runnins River. This area contains an abandoned oil-water separator east of Route 114 near the Runnins River and a pipeline to transport gasoline to Springfield, Massachusetts. There is no residential land use in this part of the census tract, therefore it is assumed that the residential population within this portion is zero.

The estimated current population within the watershed was determined using the 1990 total populations associated with each census tract. By investigating the percentage of residential land use within each census tract neighborhood versus the percentage of residential land use which exists in the watershed for those same census tracts, an approximate watershed population can be derived. It was assumed that the population density was the same throughout the census tracts (2.4 people per dwelling unit as reported in the Comprehensive Plan) and that all population resides in the residential land use areas. As previously mentioned, census tracts 105.02 and 107.01 have no residential land use within the watershed, therefore, it was assumed that they contain zero population. Therefore, the watershed population residing within census tract 103 is approximately 1,700. The watershed population in census tract 105.01 is approximately 3,200. The current watershed population in East Providence is about 4,900, or almost 10% of the city's total population. As was previously shown in Table 1, about 9% of the city's residential land usage in acres occurs within the watershed.

There are approximately 30 acres of vacant land in the watershed which is presently zoned for residential land use. This includes 16 acres in census tract 103 (Center City) which is subject to flooding and 5 acres in census tract 105.01 (Kent Heights) which is limited for development by steep slopes. Therefore, due to topography and flooding potential, this land appears to be unsuitable for development. The remaining residentially zoned vacant land is located near the former Kent Heights landfill. Because there appears to be very little suitable land currently zoned for residential usage, the watershed's East Providence population will most likely remain nearly constant. Significant population increases may only occur if either the average number of people per dwelling increases or zoning changes result in an increase of suitable residential areas within the watershed.

iii. Industrial Land Use:

Industrial land use accounts for over 35% of the total watershed land use within East Providence. Therefore, special attention should be paid to the effects that industrial uses have on stormwater quality within the watershed. For example, those industries within the watershed which should apply for and comply with stormwater discharge permitting procedures established by the Environmental Protection Agency (EPA) and the Rhode Island Department of Environmental Management (RIDEM) should be identified. Stormwater permitting is discussed in further detail in a subsequent section. The largest tracts of industrial land are the Mobil facility in the southern portion of the watershed, an area in the Kent Heights neighborhood east of the Wampanoag Trail (Route 114) along Amaral Street, and the area north of I-195.

The Mobil facility is the largest industrial facility within the watershed comprising about 800 acres. It has operated as a bulk petroleum storage terminal since 1917 and a refinery from 1920 to 1975 and is currently used as storage for gasoline products with a pipeline transporting material to Springfield, Massachusetts. The tank farm has a present capacity of 1.2 million barrels. Mobil also owns property east of the Wampanoag Trail adjacent to the Runnins River. This area includes an oil and water separator reportedly filled in during the 1970's, diversion channels, and a dam across the Runnins.

The industrial areas east of the Wampanoag Trail along Amaral Street and the Catamore Boulevard area is characterized by light industries, commercial services, and offices. There is a tributary to the Runnins River which crosses Amaral Street in the vicinity of the Consolidated Freightways facility. There are large parking areas which appear to drain directly towards the tributary and the river along Catamore Boulevard and Risho Avenue. There is also a large automobile storage yard adjacent to the tributary located on Amaral Street. The Consolidated Freightways facility on Amaral Street is one of two industries to apply for a stormwater discharge permit consistent with RIDEM policies.

The area located north of I-195 includes the Almeida Avenue and Commercial Way commercial and light industrial areas. A tributary to the Runnins crosses Almeida Avenue and runs parallel to Commercial Way. There are numerous industrial facilities and offices in this area, including the East Providence municipal garage. Some of these facilities, including the municipal garage appear to have heavy machinery and fuel storage areas. Various

businesses channel stormwater flow from their parking lots into paved drainage swales adjacent to the road and apparently leading to the tributary. The second industry within the watershed to obtain a stormwater discharge permit from RIDEM is also located in this area. Precision Art Coordinators, Inc. reportedly has two outfalls discharging surface runoff into a tributary of the Runnins River.

Approximately 120 acres of vacant land is zoned for industrial use. However, due to zoning and development constraints, there are only about 20 acres presently suitable for industrial development within the watershed. This approximate acreage was obtained from information contained in the East Providence Comprehensive Plan, 1988 and 1992 aerial photographs, field observations, and a generalized zoning map. The suitable areas appear to be located in the vicinity of Risho Avenue between Amaral Street and Catamore Boulevard, and the industrially zoned parcel northwest of the Mink Street-Wampanoag Trail intersection. However, these vacant areas may contain other physical, geographic, and regulatory constraints not investigated in this study.

iv. Commercial Land Use:

Commercial land use accounts for about 72 acres, or 5%, of the total East Providence portion of the watershed. The largest tract of commercial land use is located from Waterman Avenue south along Pawtucket Avenue to the Kent Heights neighborhood. Other smaller parcels also exist throughout the watershed. There is a small parcel of commercially zoned vacant land adjacent to the Runnins along Route 6 at the Rhode Island-Massachusetts state line.

v. Parks/Open Space Land Use:

There are about 230 acres of land presently used as parks or open space within the East Providence portion of the watershed. This accounts for about 16% of the total land use. The majority of this is adjacent to the river north of the Wampanoag Trail and includes the Gate of Heaven cemetery. Another large tract includes the former Kent Heights landfill and the interchange between Route 114 and I-195. There are about 40 vacant acres of currently zoned open space land. The majority of this is located northwest of Mink Street adjacent to the river. Another portion exists just south of the former Kent Heights landfill along the Wampanoag Trail.

vi. Public/Semi-Public Open Space:

This land use category accounts for about 7% of the watershed's land use (about 100 acres). There is presently no vacant land zoned for this category. The largest tract within the watershed is located north of Waterman Avenue and east of Pawtucket Avenue and is presently used as athletic fields near the Providence Country Day School.

B. Seekonk Land Use

A description of generalized land use for the portion of the watershed lying within Seekonk is given below. The 1986 Master Plan for the Town of Seekonk, 1988 and 1992 aerial photographs, and field observations were used to develop an approximation of generalized land use shown in Table 4.

TABLE 4
GENERAL SEEKONK WATERSHED LAND USE

Type of Land Use	Area Within Watershed (acres)	Percent of Total w/in Watershed
Residential	1,945	21.4%
Industrial	84	1.9%
Commercial	455	10.3%
Agriculture	375	8.5%
Public	349	7.9%
Vacant	2,208	50.0%
Total	4,416	100.0%

The portion of the watershed lying within Seekonk is three times larger than the portion in East Providence. Vacant land accounts for half of the land use (50.0%). The next largest land use is residential making up over 20%. Industrial, commercial, and public lands together account for about 20% of the land use. Significant commercial and business development has taken place along Route 6 in Seekonk including large retail stores with extensive parking areas. All of these developments have septic systems since there is no sanitary sewerage in Seekonk. Stormwater controls such as wet ponds are utilized at some of these locations. This area has seen significant growth and urbanization in recent years which has likely contributed to stormwater pollution problems in the Runnins River.

The upper portions of the watershed north of Taunton Avenue contains mostly vacant land and a large portion of public/quasi-public land in the Walker Street area. Many vacant areas appear to be unsuitable for development, particularly in the upper portions of the watershed. Many of these areas are wetlands and include the area from Woodward Avenue south to Ledge Road, and the area bordered by Chestnut Street, County Street, and Arcade Avenue. Agricultural land use, while nonexistent in East Providence, accounts for 8.5% (about 413 acres) of Seekonk's land use. These agricultural lands include orchards, horse farms, cultivated fields, etc. According to information from the 1986 Master Plan and aerial photos, there are numerous small areas of agricultural land use particularly in the Taunton Avenue/Chestnut Street vicinity.

C. Rehoboth Land Use

The Runnins River watershed encompasses approximately 448 acres of Rehoboth, Massachusetts. Through examining aerial photos and field observations of various areas, it appears that the dominant land use category is either open space or vacant land. The Rehoboth area in the watershed contains two roads, Pine Street and Salisbury Street. These roads contain mostly rural residential areas with some agricultural use. This area appears to contain wetlands and some new residential construction.

D. Overall Watershed Land Use

Table 5 shows various land use categories for the entire watershed based on the analysis of land uses within East Providence, Seekonk, and Rehoboth.

TABLE 5
PERCENTAGE OF GENERALIZED WATERSHED LAND USE

Type of Land Use	East Providence	Seekonk	Rehoboth	Total
Residential	5.2	14.9	0.5	20.6
Commercial	1.1	7.2	0.0	8.3
Industrial	8.7	1.3	0.0	10.0
Public	1.6	5.5	0.0	7.1
Parks/Open Space	3.7	0.0	0.0	3.7
Vacant	3.0	34.8	6.6	44.4
Agriculture	0.0	5.9	0.0	5.9
Total	23.2	69.7	7.1	100.0

The above table illustrates that although East Providence accounts for less than one-quarter of the watershed's size, it contains a significant portion of the "urbanized" area. If "urbanization" are those lands which have either industrial and commercial land usage, then about 18% of the entire watershed is "urbanized". The total "urbanization" is divided almost equally between East Providence and Seekonk, however, East Providence contains almost 90% of the watershed's industrial land use while Seekonk contains almost 90% of the commercial land use. Industrial and commercial facilities typically generate heavy metals, oils and greases, and petroleum hydrocarbons.

The majority of East Providence contains a sewerage collection system which can significantly reduce certain levels of pollutants (fecal coliform and nutrients) which can be found in areas served by septic systems. Seekonk contains significant residential and commercial land use, all with on-site individual sewage disposal systems. Typical pollutants associated with an unsewered developing community such as Seekonk include pathogens and nutrients. In areas where both sanitary sewers and stormwater drains exist, there is the possibilty of innapropriate entries and cross-connections to the storm drain system. Therefore, even though East Providence is largely sewered, inappropriate entries to the storm drain system from industrial and commercial facilities could be a possible source of fecal coliform contamination and possibly pollutants associated with industrial processes.

While generalized land use is only an indicator of potential pollutant contributions to a receiving water, any type of watershed-wide stormwater management program should focus

on issues relative to each municipality within the watershed. For example, East Providence may need to focus on identifying possible inappropriate entries from industrial facilities into the storm drain system. However, for the portion of the City which drains into the Orange Juice Creek tributary, dry weather water quality sampling (See Chapter V. Water Quality Assessment) indicates that fecal coliform contamination is not a problem. This is an indication that cross-connections to the storm drain system are not present in this sub-watershed. This drainage area consists of a portion of the commercial and industrial facilities in the Amaral Street and Catamore Boulevard areas. Therefore, any investigation of possible inappropriate entries to the storm drain system from industrial and commercial facilities should probably be focused on the Cemetery tributary subwatershed and the Commercial Way and Almeida Avenue areas in the High School tributary subwatershed.

3. Wetlands & Floodplains

The wetlands system associated with this area includes a large saltwater marsh in the Barrington River with a diverse habitat for wildlife and vegetation. The Runnins River is the source of the Barrington River, beginning below the Mobil Dam. Freshwater wetlands are also present throughout the watershed, particularly in the areas bordering the river in East Providence. These wetlands act as buffers against urban development impacts and provide diverse habitats for fish, wildlife, and birds. Encroachment by development can adversely affect the habitat of wetlands wildlife and vegetation. Wetlands are natural pollutant filters and can retain or disperse many stormwater-borne pollutants. The wetlands also provide flood storage. The capabilities of a wetland to store floodwaters and reduce their velocity and erosion potential is an important factor in urban areas. Urban development frequently creates increased rates and volumes of runoff contributing to flood damages. Increased velocities of runoff also contribute to greater erosion of the streambank. Therefore, it is important to preserve the integrity of floodplains and associated wetlands. Development within the floodplain area and adjacent to it should be limited to prevent encroachment into wetlands and water quality degradation.

Stormwater can have numerous impacts on wetlands. This includes sediment deposition which is significantly higher in wetlands receiving urban runoff. Sediments may change water depth, carry pollutants, and increase turbidity altering the wetlands' capability for providing flood storage and pollutant removal efficiency. Modifications such as grading and filling can also lead to changes in the volume of water entering or leaving the wetland

and can affect the types of vegetation and wildlife within the wetland. Metals and hydrocarbons can accumulate in the sediments and be taken up by vegetation and shellfish and filter feeders.

4. Soils

The following soil analysis is based on information obtained from the Soil Conservation Service (SCS) soil surveys of Bristol County, Massachusetts, the State of Rhode Island, and the East Providence Comprehensive Plan.

Soils in the watershed have generally poor drainage characteristics making land undesirable for development with septic systems. The wetlands areas are characterized by hydric soils which help protect adjacent areas from flooding by allowing water to filter into the groundwater supply. The hydrologic soil groups used by the SCS are defined as follows:

A. Soils having a high rate of infiltration. (Low runoff potential) Sand and loamy sand.

B. Soils having a moderate infiltration rate. Sandy loam and loam.

C. Soils having a slow infiltration rate. Silt loam and sandy clay loam.

D. Soils having a very slow infiltration rate. (High runoff potential) Clay loam, silty clay loam, sandy clay, silty clay, and clay.

It appears that the central portion of the watershed contains primarily well drained soils of hydrologic group A. The far eastern and northern parts of the watershed are predominantly composed of soils of the C and D hydrologic groups. Since urban areas are only partially covered by impervious surfaces such as parking lots and buildings, soil characteristics remain an important factor, particularly when determining the type of stormwater management practice suitable for an urban site. The process of urbanization and development has a greater effect on stormwater runoff in areas with soils having naturally high rates of infiltration, such as soil groups A and B. Development of these areas creates greater volumes of surface runoff than development of soil groups C and D.

Table 6 identifies the predominant hydrologic soil groups and Figure 3 illustrates their general locations within the East Providence portion of the watershed.

TABLE 6
EAST PROVIDENCE WATERSHED SOILS

Hydrologic Soil Group	Area Within Watershed (acres)	Percent of Total w/in Watershed
A	350	23.8%
B	268	18.2%
C	124	8.4%
D	93	6.3%
Unknown (Urban lands)	637	43.3%
Total	1,472	100.0%

Table 6 illustrates that almost one-half of the soil cover is an unknown or undefined soil group. These soils are classified as either pits, urban lands, or Udorthents. Udorthents, as defined by the SCS, consist of areas from which soil material has been removed and nearby areas in which this material has been placed. The original soil of Udorthents is generally excessively drained to moderately well drained and is usually associated with urban areas such as highways, shopping centers, and athletic fields, and are likely to have buildings and impervious surfaces. Urban lands are so altered or obscured by urbanization and structures that identification of soils is not possible. These areas also are typically covered by railroads, highways, parking lots, buildings, and industrial areas.

About one-quarter of the watershed is composed of soil group A, which are well drained soils. If areas containing these soils were subjected to development and an increase in the percent imperviousness, a greater portion of rainfall would be converted to surface runoff. These soils are primarily in the southern portions of the watershed in the area of the Gate of Heaven cemetery and north of the Mobil facility on the other side of the Wampanoag Trail. Another large portion of group A soils is located in the northwestern portion of the watershed north of I-195. The area in the vicinity of Amaral Street and Catamore Boulevard also contains A and B soils. Much of the land adjacent to the Runnins River in the lower parts of the watershed is characterized as soil group D having a high runoff potential.

Comparing soil type with vacant land in East Providence reveals that the largest tract east of the Wampanoag Trail and the Mobil facility contains large portions of soil type D, with only small areas of soil type A. Another large portion of vacant land south of the former Kent Heights landfill contains primarily soil types B and C. The vacant land in the industrial area between Catamore Boulevard and Amaral Street is a combination of soil types A, B, and C. The other large tract of vacant land located north of Waterman Avenue is composed mostly of unclassified soils and A and B soil types.

5. Landfills & Other Considerations

There are a number of surface and groundwater contamination sites within the watershed. These have been previously identified and are listed within the "Hidden River" report. Sites which may contribute to runoff water quality problems include landfills, salt storage areas, vehicle maintenance facilities, and both above ground and underground storage tanks.

The Seekonk Sanitary Landfill is located in a former gravel pit north of the Luthers Corner area of Seekonk. According to the "Hidden River" report, this landfill is administered by the Seekonk Department of Public Works and is used only for demolition materials. The 1986 Warren Avenue Drainage Study conducted for the East Providence Department of Public Works suggests that this area has also been used for disposal of fly ash.

Also within the watershed is the former Kent Heights municipal landfill which drains directly into the river. The Kent Heights Landfill site operated between 1961 and 1969. Although the exact types of wastes disposed of at the site are unknown, it was most likely a mixture of industrial, commercial and domestic waste. The approximately 24 acre area was closed in 1969 and is now a municipal park and playground with baseball fields and tennis and basketball courts. According to the Rhode Island Department of Environmental Management's Screening Site Inspection Report (1991), eleven fifty-five gallon drums containing lead and/or mercury were found on site and subsequently removed. Monitoring wells have been placed on site to measure the levels of mercury and lead which have been detected in the soil and groundwater.

A. Mobil Oil Facility/Rte. 114 Storm Sewer

In September 1992, it was discovered that gasoline contaminated groundwater was infiltrating the storm drain along Route 114 near Mink Street and entering the Runnins River. It was determined that the plume, or product, was originating from the Mobil facility and consisted, in part, of leaded gasoline. In October 1992, Mobil also discovered a petroleum hydrocarbon release into the Runnins River north of the Route 114 storm drain outfall. It was later determined (March 1993) that a petroleum hydrocarbon contamination plume is present in the Gate of Heaven Cemetery area, as well. A brief summary of the situation is provided below, however, due to ongoing efforts at the site the situation may change as remediation efforts continue.

An emergency cofferdam at the outfall of the storm drain was constructed to capture the gasoline in a containment pool. In addition, oil sorbent booms and pads were installed along the banks to minimize soil contamination and portions of the storm drain were replaced to seal it from further infiltration of groundwater. Remediation of the median strip area was also undertaken to mitigate the migration of liquid hydrocarbons in the area and to remove the hydrocarbons from the groundwater.

In February 1994, RIDEM issued a Notice of Violation and Order and Penalty to the Mobil Oil Corporation. The Route 114/Runnins River area was included along with other sites throughout the Mobil property. Violations included historical releases of over 330,000 gallons of aviation gasoline in 1941 and releases of unknown amounts as recently as 1986 and 1987 from a subsurface section of pipe. The 1941 release was the result of a broken pipeline at the former site of Tank No. 62 which was located in the northeast corner of the North Operations area tank farm, about 300' south of Route 114 across from the cemetery. Mobil records indicate that about 156,000 gallons of gasoline were recovered. The remaining 174,000 gallons either infiltrated into the soil or evaporated. Various other storage tanks at the Mobil facility within the watershed also had leaks repaired between 1953 and 1967. Groundwater flow in the vicinity of the 1941 spill and the eastern portion of the North Operations area is in a northeasterly direction indicating that the hydrocarbon plume entering the river originates from the Mobil facility.

In addition to historical releases and spills of product and subsequent contaminant migration through the Route 114 storm sewer discharging to the Runnins River, portions of the storm sewer system in the Gate of Heaven Cemetery also serve as a conduit for

petroleum constituents. This storm sewer discharges to a pond located at the northwest corner of the cemetery property which is the headwaters for Cemetery Tributary, the southernmost tributary to the Runnins River in East Providence. Although the drainage area for this tributary does not cross into the Mobil facility, the storm drain system in the cemetery appears to run south under Route 114 towards the Mobil facility. The Cemetery Tributary watershed includes most of the cemetery and portions of the Amaral Street industrial area up to Route 114. (See Appendix B - Plate 13)

Another site of concern to the Runnins River is the oil/water separator located in the vicinity of the Mobil Dam. The area consists of the oil/water separator and an abandoned pump house adjacent to the Mobil Dam. The separator was originally constructed in 1920, abandoned in 1933 and is presently being capped to reduce future leaching problems. Portions of the inlet pipe to the separator will also be removed or sealed. Any contaminated soil found at the site will be removed and disposed of off-site. This area is more fully described in the <u>Comprehensive Site Assessment Work Plan</u> completed for Mobil by Roux Associates in December, 1993.

IV. HYDROLOGIC ANALYSIS

1. Introduction

This hydrologic analysis considers the entire drainage area of the Runnins River, focusing on East Providence. This analysis presents information on climatology, streamflow characteristics, and potential impacts of future development. The information presented in this section is a summary of information contained in Appendix B - Hydrologic Analysis.

The climatology of the watershed is discussed in detail in Appendix B. It includes temperature, precipitation, snowfall depth, and rainfall frequencies which are summarized in Table 6 below. These are peak storm rainfall frequency-duration data as reported in the U. S. Weather Bureau Technical Paper 40.

TABLE 7
RAINFALL FREQUENCY DISTRIBUTION
EAST PROVIDENCE, RHODE ISLAND
(inches)

	Duration in Hours				
Annual Frequency	1	2	6	12	24
50% (2-Year)	1.2	1.6	2.3	2.7	3.4
10% (10-Year)	2.0	2.4	3.4	4.1	4.9
2% (50-Year)	2.5	3.5	4.4	5.3	6.3
1% (100-Year)	3.8	3.9	4.9	6.0	7.0

Due to limited flow data for the Runnins River, analyses of nearby hydrologically similar gaged watersheds were performed to characterize the flow regime of the Runnins River. Regression equations were also used in conjunction with the results of the regional gage analyses to develop estimated flow characteristics for the Runnins River, including mean flows, flow durations, low-flows, and discharge frequencies. The Runnins River

watershed was divided into thirteen sub-watersheds corresponding to the areas draining to the water quality monitoring stations established by the Pokanoket Watershed Alliance. See Plate 10 - Appendix B. The sub-watersheds and their drainage areas are shown in Table 8 below.

TABLE 8
SUB-WATERSHED DRAINAGE AREAS

Sub-Watershed	Drainage Area (sq. mi.)
Walnut Street	1.15
Prospect Street	0.68
Woodward Street	0.07
Greenwood Street	0.82
Arcade Avenue	0.83
Taunton Avenue	0.67
Pleasant Street	0.02
Fall River Avenue	1.61
County Street	1.22
Highland Avenue	0.29
Mink Street	1.68
School Street	0.35
Mobil Dam	0.48
Total	9.87

Estimates of mean monthly runoff were developed for the Runnins River at Fall River Avenue and School Street. These flows are plotted in Plate 4 - Appendix B. Approximate mean annual flows are 21.5 cubic feet per second (cfs) at School Street and 13.5 cfs at Fall River Avenue. Based on a regional gage analysis, a flow duration curve was estimated for the Runnins River and is shown on Plate 6 - Appendix B.

Results of the regional gage analyses were also used to develop the low-flow frequency estimate for the Runnins River, as shown on Plate 8 - Appendix B. Annual peak flow records from 1967 to 1983 at the USGS gaging station at Pleasant Street were analyzed to calculate discharge frequencies for the Runnins River. These are displayed in Table 6 - Appendix B.

A rainfall-runoff model of the Runnins River watershed was developed using the Corps of Engineers computer program HEC-1. A combination of two methods, the Modified Puls storage routing and Muskingum-Cunge dynamic routing methods were used to estimate runoff hydrographs from different rainfall events. Both methods account for watershed slope, land cover, and losses, as well as channel characteristics. The model was generally calibrated to within 10 percent of discharges developed from the analysis of the USGS gage at Pleasant Street in conjunction with discharges published in the 1979 Flood Insurance Study for Seekonk, Massachusetts. To aid in the analysis of water quality parameters, sub-watersheds were delineated and modelled at all Pokanoket Watershed Alliance sampling stations. These are shown on Plate 10 - Appendix B.

2. Existing Conditions

The HEC-1 model was first developed for the watershed's existing condition. The loss rates were estimated using the Soil Conservation Service (SCS) curve number method based on existing land use and cover within the drainage area. Rainfall for the 2, 10, 50, and 100-year 24-hour events was applied to the watershed. Runoff from each sub-watershed was routed downstream to the Mobil dam using appropriate flood routing techniques, and discharges were calibrated to the USGS gage and Flood Insurance Study data. The results of this analysis are presented in Table 7 - Appendix B.

The peak flows are significantly attenuated by storage in the wetlands and ponds of the upper watershed. Runoff fills this storage and is gradually released after peak flows have passed. This results in a hydrograph with a lower peak discharge and longer recession limb than would be expected for a similar size drainage basin without any storage (Plate 11 - Appendix B).

3. Future Conditions

The HEC-1 model was next developed for two future condition scenarios. These future condition scenarios are not forecasts of expected development and are meant only to show an approximation of what might be expected as a result of development or urbanization in different parts of the watershed. The effects of this development were modelled primarily as a decrease in loss rates in the affected sub-watersheds.

Two different future condition scenarios were analyzed. These future conditions are not forecasts of expected development and are only meant to show an approximation of what might be expected. The first scenario assumed there would be a 10% increase in the impervious surface area in the portions of the watershed above the Arcade Avenue sampling station (Plate 10 - Appendix B). The second assumes a similar increase in percent imperviousness within the subwatershed draining to the Mink Street sampling station (Plate 10 - Appendix B). This subwatershed includes the rapidly developing Route 6 area of Seekonk. Future peak discharges at the Mobil dam for these two scenarios are shown in Table 8 - Appendix B.

Development of the upper portions (10% increase of percent imperviousness) of the watershed results in a small increase in peak discharge at the Mobil dam. However, this assumes that the upstream storage areas remain unchanged. Peak discharges would be expected to increase and peak sooner if these storage areas were part of the 10% increase in percent imperviousness and were lost to development and urbanization.

Development of the Route 6 area would result in earlier peaks and larger flood discharges. This is due to peak discharges at the Mobil dam being mostly from subwatersheds south of Fall River Avenue where there is little storage and the hydrographs peak early.

Impacts from higher discharges and runoff volumes as a result of increased development in the upper portions of the watershed will affect a larger area. This is because the discharges are higher throughout the entire river system. Impacts from development in downstream portions of the watershed will be less widespread because the increased flow travels a shorter distance through the system. The future condition hydrographs are shown on Plate 12 - Appendix B.

V. WATER QUALITY ASSESSMENT

1. Introduction

An evaluation of water quality conditions in the Runnins River using existing data and past water quality reports was performed. The Runnins River is rated Class B (fishable/swimmable) by Rhode Island and Massachusetts, but fails to meet this classification along its entire length. Principal concerns are high fecal coliform and low dissolved oxygen levels. Additional concerns are heavy metals, organic enrichment, algal nutrients, and contaminated sediments. Apparent causes of these problems include a variety of nonpoint sources. The Pokanoket Watershed Alliance (PWA) has identified both a number of potential and actual sources of fecal coliform contamination. However, existing data are not specific enough to definitively identify all sources, particularly those in the tributaries or upper portions of the subwatersheds.

High fecal coliform counts in the river and also in Hundred Acre Cove are of particular concern because they contributed to closing of productive shellfish beds. Fecal coliform counts, 25 times the acceptable levels for swimming and 250 times the acceptable limits for shellfish harvesting, have been recorded in the lower reach of the Runnins River. However, it is not clear that the fecal coliform contamination of Hundred Acre Cove is solely from the Runnins River. For example, there are storm drains discharging directly to the cove, there is a lack of knowledge of mixing and tidal circulation patterns, and the original source of the coliform contamination has not been adequately identified.

This assessment is based on a review of water quality investigations conducted by the Rhode Island Division of Water Resources, the Massachusetts Division of Water Pollution Control, and the Pokanoket Watershed Alliance.

2. Tidal Hydrology

An examination of the tidal hydrology considers the Mobil Dam as the end of the Runnins River and beginning of tidewater. During normal tide ranges, the Mobil Dam, with an estimated spillway crest of 4.5 feet NGVD (National Geodetic Vertical Datum), is the upstream limit of tidal influence. Depending on astronomic high tides and storm surges, tidal influence can be expected farther upstream. However, on the average of at least once

per year it will be overtopped and saltwater will enter the river above the Mobil Dam. During storm events, significant amounts of saltwater could get into the Runnins River and saltwater flows would be expected to extend at least as far as elevation 10 feet NGVD, just downstream from Highland Avenue (Route 6).

Hundred Acre Cove, one of the three largest salt marshes in the State of Rhode Island, is located below the Runnins River and has been designated by USEPA as a priority wetland. Freshwater from the Runnins River, which discharges to the Barrington River, along with runoff drainage from the cove's watershed, mixes with and dilutes seawater. Direction and quantity of flow in the Barrington River depends more on tidal influences and variations than on freshwater inputs from coastal drainage and the Runnins River. Current sampling conducted by the Pokânoket Watershed Alliance in the Runnins River and Hundred Acre Cove is limited to grab samples which are collected independently of travel time between stations or the tide level in the cove. This sampling effort is too simplistic to determine whether water quality problems originate in the upper watershed and are brought down the river, originate within the cove's watershed, or are brought in with the tide. Sampling over selected storm hydrographs, with sampling time at stations correlated to travel time, and gaging of streamflow and tidal flux, would be more useful in addressing whether the Runnins River is a major contributor to problems in the cove. The Runnins River watershed accounts for over 70% of Hundred Acre Cove's watershed, however, pollutant contributions from the remaining 30% have not yet been identified.

Most mixing and flushing of Hundred Acre Cove depends on tidal action. Freshwater mixing is expected to be rather limited in the eastern part of the cove below the spit of land known as "The Tongue" which separates the deeper part of Hundred Acre Cove from the main channel. Although water quality problems in Hundred Acre Cove are an increasing concern, apparently there has been no determination of mixing, turbidity, salinity, stratification, and water circulation patterns within the cove. Without such knowledge, it is difficult to evaluate the extent that water quality problems originating in the Runnins River are having on Hundred Acre Cove.

3. Existing Water Quality Conditions

A number of water quality surveys have been conducted within the last several years. The studies show fecal coliform are being observed in the Runnins River even during

dry weather conditions. Appendix C summarizes the water quality surveys previously conducted and some key points from these surveys are summarized below.

In 1966 the Rhode Island Department of Health sampled the Runnins and Barrington Rivers during a dry weather period. Runnins River results showed very poor water quality with dissolved oxygen levels ranging down to close to depletion and coliform levels ranging up to those found in wastewater. These conditions indicate possible cross connections of sanitary sewers to a storm drain system which could occur in areas such as East Providence, or severely overloaded and malfunctioning septic systems which could occur in areas such as Seekonk. In 1988 and 1989, the USGS analyzed general water quality parameters in rivers throughout Rhode Island. It showed the Runnins River to have some of the poorest water quality among the fifteen rivers sampled under the program. Among the fifteen rivers, samples from the Runnins River exhibited the lowest concentrations of dissolved oxygen. The Runnins River samples also contained the second highest manganese concentration, but otherwise average concentrations of other metals.

The State of Rhode Island conducts bacteriological monitoring of shellfish harvesting areas to maintain certification for shellfish harvesting under the National Shellfish Sanitation Program. Hundred Acre Cove is located in Shellfish Growing Area Number 2 which includes the Barrington, Palmer, and Warren Rivers. The most recent Shoreline Survey Reappraisal Report conducted in 1990 indicates that bacteria loadings originate from somewhere in the Runnins River watershed, and that the source may be constant and not wet weather dependent. However, as previously described, there may be other potential sources, including storm drains discharging directly to the Cove and tidal mixing.

The Massachusetts Department of Environmental Protection (MADEP) conducted water and sediment sampling in 1991 and 1992, respectively. The water quality samples indicated that low dissolved oxygen, high fecal coliform counts and significantly elevated nitrogen levels were evident. These are dry weather samples and wet weather conditions were not documented.

According to the MADEP samples, relatively high levels of fecal coliform occurred at Pleasant Street, the Grist Mill, a storm drain leading from the Ann & Hope retention pond on Route 6, and in the river behind Price Club. Although the levels behind Price Club are elevated, MADEP suggests that this could be due to the elevated levels originating from the

storm drain near the Ann & Hope drainage pond. Furthermore, the flow from the retention pond was described as "only a trickle". MADEP speculates that the cause of elevated fecal coliform levels may be due to cross-connections with a sanitary sewer, overloading of the septic systems resulting in contaminated groundwater, or "even rodents dwelling in the drain pipe."

Fifty percent of the samples collected in June 1991 and 80% collected in July 1991 exceeded the Class B standard for fecal coliform levels. The highest instream level of 2,200 coliforms per 100 ml occurred below the Grist Mill Pond dam. High levels exceeding the Class B limit of 200 coliforms per 100 ml were also found at Pleasant Street (1,040 coliforms per 100 ml), below Highland Avenue (960 coliforms per 100 ml), and School Street (300 coliforms per 100 ml).

In addition, water quality sampling was conducted within one day of the MADEP sampling in the vicinity of Price Club. This sampling was requested as part of the Order of Conditions issued by the Seekonk Conservation Commission for the Price Club Plaza project. The assessment included monitoring six groundwater wells and two surface water drainage ditches. This monitoring found "no consistent trend of bacterial contamination of surface water or groundwater is apparent." However, consistent moderate concentrations were found in the wells adjacent to Route 6 indicating possible contamination from offsite individual sewage disposal systems. The fecal coliform level obtained the day before the MADEP sampling was 3800 colonies/100 ml, which is considerably higher than the 240 colonies/100 ml observed by MADEP in the same area the next day.

High levels of Total Kjeldahl Nitrogen (TKN) (between about 1.0 and 3.0 mg/l) were observed from the MADEP samples. Nitrogen in septic system effluent is primarily in the form of TKN which is the sum of organic and ammonia-nitrogen. Ammonia-nitrogen levels for these same samples are consistently lower (between 0.15 and 1.0 mg/l) and follows the same pattern as the TKN levels. Therefore, the majority of TKN is probably in the form of organic-nitrogen. Since the organic portion of TKN is commonly broken down in septic systems to ammonia, the high levels of organic-nitrogen may be an indication that septage is reaching surface waters before full treatment is accomplished. However, fertilizers may also contribute to elevated nitrogen concentrations. MADEP speculates that high nitrogen concentrations in the upper watershed (above Taunton Avenue) could be due to malfunctioning septic systems, or horse barns and pastures.

Relatively high nitrate-nitrogen concentrations (between about 0.4 and 1.9 mg/l) also exhibit a similar pattern to the TKN concentration samples. Ammonia-nitrogen from septic tanks is converted to nitrate-nitrogen within the soil profile below the leaching field. Nitrate-nitrogen often ends up in groundwater and the high concentration occurring during a dry weather period could indicate potential groundwater contamination by septic system effluent reaching surface waters. However, fertilizer use is also another possible source of nitrogen contamination.

Sediment samples were collected at eighteen sites in June 1992. Appendix C contains a summary of the data and a description of how these values compare with various sediment classification guidelines. (See Table 4, Appendix C.) As noted in Appendix C, copper levels were elevated at three of the eighteen sampling sites. One of these sites is the Grist Mill Dam where levels were between 44 and 46 parts per million (ppm). However, samples obtained upstream at Pleasant Street indicate levels less than 8 ppm. Possible sources of copper within this stretch of river from Pleasant Street to the Grist Mill Dam include traffic related sources (e.g., brake linings, engine exhaust and emissions) and pesticides. Pesticides could be a potential source from the golf course which the river flows through between Pleasant Street and the Grist Mill Dam and should be further investigated. The golf course borders practically this entire stretch of river. Traffic related sources and automotive emissions are also a possibility due to parking areas adjacent to the Old Grist Mill Pond and the intersection of Route 114A and Arcade Avenue.

This pattern of relatively low copper levels at Pleasant Street and elevated levels at the Grist Mill Dam is also exhibited for lead, arsenic, zinc, iron, and nickel. Arsenic sources include herbicides which could originate from the golf course. However, primary sources of lead, zinc, iron and nickel are most probably traffic and vehicle related from motor oil, emissions, tires, brake linings and rust.

The highest levels of copper (75 ppm) were found upstream of the Mobil Dam. Copper levels collected further upstream within the Orange Juice Creek tributary (not in the main river channel) exhibited low levels (12 ppm). Differences between these two samples could be related to traffic and vehicular sources, particularly runoff due to the School Street-Mink Street-Wampanoag Trail intersection. Furthermore, the storm drain system for the

Wampanoag Trail discharges directly to the river. This pattern of high levels at the Mobil Dam and lower levels upstream at the tributary are consistent for lead, arsenic, nickel, zinc, iron, and aluminum.

In addition, several trace metals and organic compounds were found in sediment samples taken from the Orange Juice Creek tributary, downstream from the former Kent Heights landfill. There are also indications of high levels of zinc at a sampling site in Orange Juice Creek near the Catamore Boulevard industrial park. Zinc is a parameter related to motor vehicles and traffic sources of runoff and this tributary contains large parking areas and an auto salvage and storage operation adjacent to the tributary.

Although these sediment samples can indicate general patterns of runoff contamination, further sampling is required to fill gaps in data. For example, there was no MADEP sampling conducted between Orange Juice Creek tributary and the Mobil Dam.

The New England Interstate Water Pollution Control Commission (NEIWPCC) has undertaken the Runnins River Initiative to assess and understand effects of stormwater runoff on the Runnins River and to identify areas of special concern. To date, only dry weather samples have been collected. However, the dry weather samples showed elevated nutrient levels and high fecal coliform counts more typical of wet weather than dry. Rainfall for August 1992 was about 2" above normal but with no significant rainfall two weeks prior to the dry weather sampling event. Therefore, high groundwater table and subsurface flow conditions may make the data more representative of wet weather conditions. The Pokanoket Watershed Alliance (PWA) conducted this dry weather sampling for NEIWPCC. This trend of high fecal coliform levels appears to be consistent regardless of precipitation. Fecal coliform counts obtained at various sampling points by the PWA show little correlation between rainfall and fecal coliform levels.

According to the dry weather sampling conducted in August 1992 by the PWA for NEIWPCC, there are significant fecal coliform problems throughout the river. At stations located from Taunton Avenue to the Mobil Dam, fecal coliform exceeded the Class B standard of 200 colonies/100 ml in all cases. The largest increase in fecal coliform occurred between the station downstream from the Grist Mill and School Street. This is the area containing the highly developed Route 6 area of Seekonk and most of the portion of the subwatershed which drains East Providence. Fecal coliform levels jumped from 250

colonies/100 ml at the Grist Mill to 4,700 colonies/100 ml at School Street. This indicates that within this reach of river, there is a significant contribution of fecal coliform. In fact, for this sampling period, there was a fecal coliform contribution of 950 colonies/100 ml originating from the 30" drain pipe along Mink Street in Seekonk. This section of river also contains the Orange Juice Creek subwatershed which drains about 25% of the East Providence area. However, according to the dry weather results, the Orange Juice Creek tributary sampling station was the only station to record fecal coliform levels below 200 colonies/100 ml (40-60 colonies/100 ml).

This data is an indication that significant fecal coliform contamination may not be originating from the Orange Juice Creek tributary drainage area on a regular basis. However, this does not include all of East Providence and should be confirmed with additional and more frequent monitoring. Although there have been intermittent wastewater pumping station overflows from East Providence which contribute to the fecal coliform levels of the river, it appears that none occurred during this sampling period.

The PWA also performs sampling at 15 stations - twelve on the main stem of the river, and three within Hundred Acre Cove. The data reviewed for this assessment covers a twelve month period from June 1992 to May 1993, with the exception of fecal coliform which was monitored through December 1993. To interpret the data and simplify the results, the river has been divided into four reaches, as described below. This data interpretation is more fully described in Appendix C - Water Quality Assessment.

The Upper Reach comprises the sampling stations located at Walnut, Prospect, Woodward and Greenwood Streets. Fecal coliform exceeded the acceptable level of 200 colonies/100 ml at all four sites at least once over this period. Dissolved oxygen content was fairly constant, however, from May to November the dissolved oxygen levels for this reach were very low and posed a threat to fish. However, low flows in the upper portion of the river during this period limits the threat to fish.

The Middle Reach comprises the sampling stations at Arcade, Taunton, and Fall River Avenues, and the USGS staff gage at Pleasant Street. Fecal coliform counts in this reach are high. Out of 54 tests performed over 18 months, only 13 resulted in acceptable fecal coliform levels. The dissolved oxygen levels remained above the acceptable level of 5 mg/l for most of the year.

The Lower Reach comprises sampling stations located at County Street, Highland Avenue, Mink Street, an outfall at Mink Street, and School Street. This reach is the highest levels of fecal coliform contamination. Some of the levels are 25 times the acceptable limit for fishable and swimmable waters. The dissolved oxygen content for the period July to October were extremely low, indicating high organic loading and posing a threat to fish.

The last reach is Hundred Acre Cove. These sampling stations included one at the WPRO radio tower and two in Hundred Acre Cove. Over the 18 month period of fecal coliform monitoring, fecal coliform exceeded acceptable levels for 7 months. The two sites within Hundred Acre Cove rarely exceeded acceptable levels. The dissolved oxygen levels within this reach complied with the minimum limit for the entire year it was monitored.

4. Pollution Sources

Water quality in the Runnins River is primarily degraded by nonpoint sources. There are no permitted point source discharges in the watershed, such as municipal wastewater treatment plants. However, there are two stormwater discharge permits issued to East Providence industries. Based on a review of existing water quality data, fecal coliform is a major concern in the Runnins River and Hundred Acre Cove. The source of fecal coliform is feces from warm-blooded animals. These can end up in the Runnins River from a variety of sources by a number of pathways. Direct discharges may result from inappropriate connections of sanitary waste lines to the storm drain system, overflows from sewage pumping stations, leakage from sewer pipes, seepage from individual disposal systems (septic tanks), and runoff carrying feces from wildlife. Groundwater recharged by flows contaminated with fecal coliform from these sources can convey fecal coliform to the river if there is a pathway with poor filtering properties. Some potential sources were discussed above when reviewing the existing data.

It is not known to what extent the various sources are contributing to the problem. For example, although there are no documented cases of illicit or improper sanitary sewer connections to the storm drain system, it has not been fully investigated. As previously stated, although water quality problems in Hundred Acre Cove are an increasing concern, there has been no determination of contributions to the cove from storm drains discharging directly to it, or a determination of mixing, turbidity, salinity, stratification, and water circulation patterns within the cove. Without such knowledge, it is difficult to evaluate to

what extent water quality problems originating in the upper watershed are conveyed downstream below the Mobil Dam.

The existing data, such as that collected by the PWA, is inconclusive for determining specific nonpoint sources of fecal coliform or for apportioning the fecal coliform concentrations to either East Providence or Seekonk. Although this data is inconclusive, possible sources of fecal coliform contamination within East Providence have been qualitatively identified below. These possible sources include:

1. The unsewered areas of East Providence which have been previously identified in the City's 1992 Comprehensive Plan report. This report shows that, within the Runnins River watershed, there are approximately 14 residential units and 12 commercial facilities which are not presently connected to the sewerage collection system. According to this report, most of these facilities are located in the Amaral Street and Boyd Avenue areas. Inspections of existing septic systems should be accomplished to determine if there is a need for any further investigation into this possible source.

2. Sewage pumping station overflows have been previously documented and are intermittent. They occur only occasionally at one pumping station within the watershed (Pumping Station No. 16, Wannamoisett Road) and are not a major problem.

3. Under certain conditions, areas of excess infiltration into the sewerage collection system could possibly be susceptible to exfiltration. Sections of the sewer system experiencing excessive infiltration have already been identified in an infiltration/inflow study conducted by Hayden/Wegman in 1988. Therefore, corrective measures taken in these areas to solve infiltration problems would also eliminate the potential for exfiltration to the local groundwater and subsequently the Runnins River.

4. Inappropriate sewer connections can be identified through an analysis and investigation of dry weather flows at storm drain outfall pipes and manholes. See section VII.1.B.vi. for further guidance on identifying non-stormwater entries (e.g., sanitary sewers) to a storm drain system. However, for the portion of the City which drains into the Orange Juice Creek tributary, dry weather water quality sampling (See Chapter V. Water Quality Assessment) indicates that fecal coliform contamination is not a problem. This is an indication that sanitary sewer connections to the storm drain system probably don't exist in this subwatershed. Therefore, any investigation of possible inappropriate entries to the storm drain system should probably be focused on the Cemetery and High School tributary subwatersheds.

5. Fecal coliform from local wildlife is a potential source of contamination. As previously discussed, MADEP has speculated that rodents dwelling in a pipe could be a possible source of fecal coliform contamination at a particular sampling station. The ratio of fecal coliform to fecal streptococci may give an indication of the sources of pollution (man versus animal). Man has a coliform to streptococcus ratio greater than four while many animals (e.g., seabirds) have a ratio less than one. However, the magnitude of this potential source is unknown and could apply equally throughout the Runnins River watershed.

Although these possible sources of fecal coliform contamination have been identified, it is unlikely that East Providence is a significant contributor of fecal coliform. However, sources such as inappropriate entries and remaining septic systems should be investigated to definitively eliminate them as possible contributors of fecal coliform contamination. This can be accomplished through stormwater monitoring of outfalls and inspection and possible dye testing of existing septic systems.

5. Conclusions of Water Quality Assessment

This assessment found that Runnins River water quality is quite poor and does not meet the goals of fishable and swimmable. Fecal coliform contamination is the main problem in the Runnins River and Hundred Acre Cove. However, it is not clear that the coliforms contaminating Hundred Acre Cove come solely from the Runnins River. Shoreline surveys have identified 30 storm drains discharging into the Hundred Acre Cove area from Barrington which must be considered when determining the sources of contamination to the cove.

Much of the existing data is inconclusive for determining specific nonpoint sources of fecal coliform or for apportioning the fecal coliform concentrations to either East Providence or Seekonk. The PWA, between March 1992 and May 1993 identified six major sources of fecal coliform, only one of which was located within East Providence. This was the sewage pumping station overflows first identified in March 1992. Between April 1992 and May 1993, five other significant sources of fecal coliform contamination were identified. Two were in Barrington, Rhode Island, and three in Seekonk, Massachusetts.

Based on the existing information, it is unlikely that East Providence is a significant source of the fecal coliform contamination found within the Runnins River. However, potential sources of fecal coliform contamination which could originate in East Providence have been qualitatively identified and may need further investigation.

Appendix C presents an outline for a nonpoint source pollution study to determine the sources of fecal coliform contamination in Hundred Acre Cove and subsequently within the Runnins River watershed. However, presented below is a stormwater monitoring plan outline specifically for the East Providence portion of the Runnins River watershed.

A. East Providence Stormwater Monitoring Plan Outline

This stormwater monitoring plan is meant to characterize the physical and chemical parameters of stormwater which originates in East Providence, to supplement the data already collected by other groups or agencies, and as a means of determining nonpoint sources of pollution within the subwatersheds draining East Providence.

It is anticipated that the number of sampling locations will include: the 7 storm drains previously identified by shoreline surveys, 1 sample location for each tributary (3 total), and 2 sample points within each of the three tributaries (6 total) at either a manhole or subwatershed outfall, for a total of 16 water quality sampling stations.

1. Identify sampling locations for wet and dry weather activities based on land use and existing information. Identify relevant water quality parameters for sampling and measurement (e.g., fecal coliform, temperature, hardness, nitrogen, metals, etc.)
   Estimated Cost = $3,000

2. Field check the potential monitoring sites for ease of obtaining samples and flow measurements.
   Estimated Cost = $1,000

3. Collect and analyze water quality samples during two storm events and during one dry weather period. This includes the installation of a rain gage and measurement of flows. The dry weather samples will aid in identifying inappropriate entries (e.g., illegal connections) to the stormwater drainage system. Estimated Cost = $70,000

The total estimated cost for sampling two wet weather events and one dry weather event is $74,000. This estimated cost is not definitive and depends on available manpower, equipment, sampling methods, and analyzing techniques. For the purpose of the above outline, it is assumed grab samples will be suitable.

VI. Pollutant Loading Analysis

1. Effect of Land Use, Soil Type, & Watershed Population on Pollutant Concentrations

The effect that land use, soil type, and population density have on pollutant concentrations has been documented in various studies, particularly within the Nationwide Urban Runoff Program (NURP) study.

The NURP study found that broad land use categories such as "industrial" and "commercial" are of little use in "predicting urban runoff quality at unmonitored sites or in explaining site to site differences where monitoring exists." Land use categories generally classify the most predominant activity which occurs in that area. Specific sites grouped into a single land use category also contain varying topography, soil type, and percent imperviousness. Pollutant concentrations are dependent on specific types of industries or commercial businesses occurring within a watershed and other physical aspects mentioned above. Therefore, there may be considerable variability in pollutant concentrations and loadings within a single land use category such as "industrial" or "commercial".

The percent imperviousness and amount of precipitation are two important factors influencing pollutant loadings from large commercial and residential drainage basins. Pollutant concentration data obtained from the NURP study can be used for planning level purposes. Pollutant concentrations from large residential and commercial areas are roughly equivalent, however, the amount of percent imperviousness is an important factor in determining pollutant loads. Central business districts and commercial areas typically have a high degree of imperviousness and the highest pollutant loadings per unit area. Residential lands have significantly lower percent imperviousness and associated pollutant loadings compared with commercial areas.

The pollutant concentrations used for this analysis are national averages of various pollutant parameters obtained from the NURP study. This data is ideally suited for planning level studies such as this. Average pollutant concentrations have also been documented for older urban areas and central business districts, such as exists in East Providence. The pollutant concentrations (biochemical oxygen demand (BOD) and metals (e.g., lead, copper, zinc)) associated with older urban areas and central business districts are frequently higher than new suburban developments and the national average.

Soil type is another characteristic which may affect pollutant quantities. The findings of the NURP study state that while soil type has the potential to influence pollutant concentrations, it appears to have little use in predicting stormwater pollutant characteristics of unmonitored sites. Population density also has the potential to influence pollutant concentrations, however, the NURP findings indicate that this factor does not have "consistent significance in explaining observed similarities or differences among individual sites." Therefore, pollutant loads should be based on a specific site's percent imperviousness, runoff coefficient, mean pollutant concentrations, and rainfall volume.

Pollutant transport was not specifically investigated in this study. However, certain modes have been identified, in particular paved drainage swales in the vicinity of Commercial Way. There are also paved swales throughout the watershed particularly adjacent to roadways, culverts, and bridges. Some of these are located on secondary roads in the upper portion of the watershed in Seekonk where the river crosses under the road. There are also paved swales at the River Road/School Street crossing along the East Providence-Seekonk boundary. Other potential pollutant transport modes include direct runoff from facilities adjacent to the river or its tributaries and parking lot storm sewers drains discharging untreated stormwater runoff in the vicinity of the river.

2. General Sub-Watershed Pollutant Loadings

Gross pollutant loadings for subwatersheds encompassing East Providence and Seekonk were estimated using an empirical pollutant loading method known as the Simple Method. This methodology is capable of predicting pollutant loadings for various planning conditions and is more fully described in "Controlling Urban Runoff: A Practical Manual For Planning & Designing Urban BMPs" (Schueler, Thomas R., 1987).

Storm pollutant loadings from a site are calculated using rainfall depth (inches), a runoff coefficient which expresses the fraction of rainfall which is converted into runoff, pollutant concentrations (mg/l), and the area of the site (acres). This method provides an easy and versatile means of estimating pollutant loads and is considered sufficiently accurate and reliable for making planning level decisions in the absence of detailed urban runoff water quality monitoring. This methodology utilizes the curve numbers developed in the hydrologic analysis (Appendix B) and general pollutant concentrations developed during the NURP study to obtain pollutant loadings.

Pollutant concentration datasets can be obtained through various literature sources. One such dataset are the findings of the NURP study. These pollutant concentrations were obtained from over 2300 storms monitored at 22 project sites across the nation. The pollutant concentrations used for this analysis include concentrations for newly stabilized suburban sites, older urban areas, business districts, highway runoff, and national averages obtained from the NURP study. The Simple Method is primarily intended for use on sites less than a square mile in area. Each subwatershed was divided between East Providence and Seekonk and although the Mink Street subwatershed in East Providence exceeds this limitation by 0.17 square mile, it is acceptable for this analysis.

The subwatersheds for which pollutant loadings were developed are County Street, Highland Avenue, Mink Street, School Street, and Mobil Dam. These are shown on Plate 10 - Appendix B. These subwatersheds were chosen for the pollutant loading analysis because they encompass the majority of urbanized area within the Runnins River watershed and include all of East Providence. The methodology for this included assigning each portion of a community's subwatershed typical pollutant concentration values based on the type of land use in that area (e.g., central business district, older urban area, etc.).

The analysis presented here shows gross pollutant loadings generated from the various subwatersheds. Further refinement of initial pollutant concentrations to be used for each portion of the subwatershed and its associated runoff from the same area is required. This analysis also does not specifically include pollutants from highway runoff which can be significant. Only through extensive water quality monitoring of stormwater runoff can actual pollutant loads from the subwatersheds be obtained and compared.

Table 9 lists typical pollutant parameters and the pollutant loads associated with all of the urbanized subwatersheds generated by a 2-year, 24 hour rainfall event. The parameters used for this analysis included: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), lead (Pb), total nitrogen (TN), and total phosphorous (TP). These and other pollutants are standard pollutants which characterize urban runoff. The loadings are meant to be used only to identify possible loadings and not as measurements of the pollutant quantities actually originating from within the watershed. The pollutant loads are dependent on watershed size (acres), the curve number and percent imperviousness associated with it, and appropriate pollutant concentrations. The curve numbers are based on the Soil Conservation Service's land cover definitions obtained from

Technical Report No. 55 (TR-55). These include typical land uses (e.g., industrial, open space, etc.) with varying percent imperviousness.

The estimated pollutant loads listed in Table 9 are only an indication of theoretical pollutant loadings associated with a typical 2-year, 24-hour rainfall event. Furthermore, it does not mean that the entire loading reaches the Runnins River. This example is meant only to illustrate the possible magnitude of pollutant loadings. Refinement of the parameters (e.g., curve numbers, pollutant concentration values) needed for the Simple Method are required to provide a better estimate of pollutant contributions from each municipality and each subwatershed. Wet weather sampling is also required to characterize the type and concentration of pollutants.

TABLE 9
THEORETICAL POLLUTANT LOADS (LBS.) ASSOCIATED WITH URBAN LAND IN THE WATERSHED FOR A 2-YEAR, 24 HOUR RAINFALL EVENT

Pollutant	Estimated Pollutant Loading (lbs.)	
Parameter	East Providence	Seekonk
Biochemical Oxygen Demand (BOD)	800	3,200
Chemical Oxygen Demand (COD)	15,200	5,700
Total Suspended Solids (TSS)	18,000	15,800
Lead (Pb)	40	45
Total Nitrogen (TN)	900	300
Total Phosphorous (TP)	85	20

The above table shows that East Providence, while accounting for less than a quarter of the entire watershed, contributes a significant quantity of pollutants within the portion of the watershed covering urbanized areas. As previously stated within the land use section of this report, East Providence contains a significant portion of the urbanized area of the watershed including 90% of the industrially classified land.

The higher estimated BOD loadings in Seekonk are due to higher initial BOD concentration literature values associated with commercial areas. However, further refinement and investigation of the use of these values and the character of the subwatersheds is recommended. Higher estimated loadings of COD in East Providence are due mostly to higher COD concentrations observed in older urban and residential areas compared with national average values. These differences in concentrations may reflect differences between East Providence and the more recently developed portions of Seekonk.

Sediment loads are generally related to watershed size and degree of stabilization. The largest sediment loads are usually generated during the construction phase. Therefore, the total estimated suspended solids load in Seekonk where most new development is occurring is probably low and may not be representative of actual conditions.

Lead was chosen as an indicator of trace metals which may be generated. Older urban areas such as East Providence and commercial business districts such as Seekonk (Route 6) typically contain high concentrations due to traffic related sources. This was reflected in the estimated pollutant concentration values.

The estimated nitrogen and phosphorous loads for East Providence are higher than that for Seekonk. This is due to the initial concentration levels being higher for older urban areas such as East Providence. For example, phosphorous concentrations are typically higher for older urban areas than for newer developing suburban sites. Typical sources of phosphorous include, but are not limited to, traffic related sources such as motor oil additives, organic debris, lawn runoff, and atmospheric deposition.

The following is an example showing the possible increase in various pollutant loadings if a particular parcel of vacant, undeveloped land is developed for residential and commercial use. For this analysis it was assumed that a 20 acre parcel of vegetated vacant land (e.g., the vacant land adjacent to the Wampanoag Trail) would be developed into a mix

of townhouses and commercial applications. Pollutant loads were developed using the Simple Method previously described and a 2-year, 24-hour rainfall event. Two sets of pollutant concentrations were used; one for the natural or vegetated condition, and one reflecting a new suburban development. The following table shows the differences between the existing and future conditions.

TABLE 10
UNDEVELOPED VERSUS DEVELOPED
ESTIMATED POLLUTANT LOADINGS

Pollutant Parameter	Estimated Pollutant Loading (lbs.) Undeveloped Condition	Developed Condition
Biochemical Oxygen Demand (BOD)	0	60
Chemical Oxygen Demand (COD)	190	405
Total Suspended Solids (TSS)	0	285
Lead (Pb)	0	0
Total Nitrogen (TN)	4	25
Total Phosphorous (TP)	1	3

As expected, estimated pollutant loads are greater for the developed condition. This illustrates typical effects development can have on stormwater runoff from a site.

Although a pollutant loading analysis was not part of the Scope of Services defining the conduct of this Section 22 study, it does provide an indication of what may be required to estimate pollutant loadings throughout the watershed. It is recommended this or a similar methodology be utilized to estimate pollutant loadings throughout the watershed. Parameters required for this loading analysis should be refined to obtain a more accurate estimate

of pollutant loadings originating from subwatersheds. This includes an accurate determination of the type of land cover, soil type, percent imperviousness and estimated runoff from the site.

A pollutant loading analysis can be used in an urbanized area such as East Providence to rank or prioritize those subwatersheds or outfalls contributing the greatest pollutant loadings. The following steps can be used for this determination:

1. Delineate drainage areas of natural subwatersheds and major storm drain system outfalls.

2. Refine typical pollutant concentration values and runoff characteristics to be used for each subwatershed or drainage area by accurately characterizing the land use and cover type associated with a particular parcel.

3. Utilize a pollutant loading methodology (e.g., Simple Method) to identify and rank critical subwatersheds and outfalls based on those which contribute the greatest pollutant loads. Pollutant loadings can then be estimated for major storm drain system catchbasins or manholes within a critical subwatershed to identify sampling needs or develop mitigation strategies.

4. Develop design and siting of control strategies. For example, this could include implementing best management practices at specific sites (multi-site), or a subwatershed (regional) approach requiring an end-of-pipe solution. Control strategies can be chosen based on their respective pollutant removal efficiencies. Cost effectiveness can be determined using either the multi-site or regional approach. The City, as part of a stormwater management program, must establish its goals and objectives for pollutant reductions. Pollutant removal efficiencies for various best management practices are provided in the following sections. For example, based on the water quality assessment presented in this report, fecal coliform is a major concern. If fecal coliform were originating in East Providence, possible mitigation strategies could

include: 1) certain infiltration methods which have relatively high rates of removal for bacteria, and 2) an investigation of inappropriate or illicit connections to the storm drainage system. A pollutant loading analysis can help determine where further sampling or mitigation may be required.

VII. IDENTIFICATION & EVALUATION OF STORMWATER MANAGEMENT OPTIONS

1. Stormwater Control Strategies

Based on information contained in this report and previous studies, various solutions have been identified. Nonpoint source pollution control strategies proceed from two basic principles involving land use. The first is to increase the ability of the land to retain water allowing the soil to reduce pollutants in the water. The second is to minimize the types and quantities of pollutants in the runoff which is generated at a site. Possible solutions which are discussed are divided into the following four stormwater control strategies which encompass these two principles:

A. Regulatory & Institutional Controls
B. Source Controls
C. Infiltration Methods
D. Storage Methods

The information contained here is derived primarily from the Rhode Island Stormwater Design and Installation Standards Manual and Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Specific recommendations for each of the four stormwater control strategies are provided in section "IX. Recommendations".

A. Regulatory and Institutional Controls

Regulatory and institutional controls include using zoning ordinances, land use regulations, and coordination and cooperation among municipalities and other political entities sharing the watershed. Regulatory and institutional controls frequently require a commitment to sound stormwater management planning by a local political entity. This commitment is necessary for the implementation of a comprehensive stormwater management program and requires coordination and cooperation among the municipalities in the watershed. Outlined below is a method of coordination, cooperation, and communication which may be suitable for the Runnins River watershed. A watershed management district is

a method of commitment which can enhance cooperation, coordination and communication among the various municipalities and agencies using and regulating the watershed's natural resources.

A funding mechanism is also required to accomplish this. There are many sources of funding available, however, a dedicated source of funds, such as that provided by a stormwater utility, is sometimes necessary for a successful stormwater management program. Therefore, this section also provides information pertaining to stormwater utilities.

i. <u>Runnins River Watershed Management District:</u>

Coordination, cooperation, and communication among agencies and municipalities sharing the natural resources of a watershed is an integral part of stormwater management. This is a common theme for a sound stormwater management plan and requires a watershed-wide approach involving various public and private entities. Stormwater pollution is not a problem confined by jurisdictional boundaries, therefore, governments sharing a watershed should consider cooperating under the authority of a regional entity such as a watershed management district.

Due to the nature of the Runnins River watershed extending over municipal and state boundaries, a mechanism for providing management and cooperation among entities sharing the watershed's natural resources should be investigated. A Runnins River Watershed Management District (RRWMD) could be established to accomplish this. The primary objective for establishing such a district would be to provide enhanced coordination and cooperation at the local level while dealing with issues such as balancing the objectives of development, urbanization, and economic growth with the need to protect the natural resources and improving the water quality of the Runnins River.

The RRWMD could consist of representatives from state agencies such as the Rhode Island Department of Environmental Management and the Massachusetts Department of Environmental Protection, officials from watershed municipalities (including city and town planners, conservation officers, etc.), local citizens groups (e.g., Pokanoket Watershed Alliance), and other interested parties. Members should include the City of East Providence, Rhode Island, and the Town of Seekonk, Massachusetts. The towns of Rehoboth, Massachusetts and Barrington, Rhode Island should also be involved in an advisory capacity.

The creation of such a district could be the first step in developing a watershed-wide stormwater management strategy with associated goals, objectives, guidelines and implementation procedures. This strategy can be based on the information contained in this report.

This example is presented as an illustration of what could be implemented as a means of coordinating stormwater management efforts among the various watershed users.

ii. Stormwater Utility:

The City of East Providence should investigate various funding mechanisms to develop, implement, and enforce a comprehensive stormwater management program not only for the Runnins River watershed, but throughout the city. One method of possible funding is through the creation of a stormwater utility. Although not common within the New England area, a stormwater utility can be a main source of funding for a comprehensive stormwater management program. Therefore, the City of East Providence should investigate the feasibility of creating a stormwater utility as a means of funding:

1. the implementation and enforcement of a city-wide stormwater management program,

2. the City's participation in a watershed management district such as the RRWMD, and

3. the National Pollutant Discharge Elimination System (NPDES) permit application process, if necessary. The NPDES is discussed in the following section.

Any method of funding, including the stormwater utility concept, should be approached as part of a comprehensive stormwater management plan adopted by the city and should not be limited to the Runnins River watershed. For example, the city also experiences drainage problems in the Southeast Drainage District south of the Mobil facility. The stormwater utility concept illustrates only one possible method of funding a stormwater management program.

A stormwater utility is an organization that provides financing of stormwater system operations, maintenance, and capital improvements and a dedicated source of revenue to collect, treat, and dispose of stormwater as well as addressing issues such as water quality degradation within the watershed. The utility concept could also be used as a method of financing future regulatory actions such as phase 2 of the NPDES which may require municipalities with a population of 50,000 or greater that own or operate separate stormwater conveyance system apply for a permit. The NPDES permit and application process is more fully described in the following section.

Establishing a stormwater utility requires defining and documenting the problems and issues relating to stormwater, including defining both flooding and water quality problems. The following steps may be used by the City as a guideline in establishing a stormwater utility.

1. Define and document problems and needs of the community.

2. Develop a comprehensive stormwater management plan based on the framework outlined in this report. As part of a comprehensive stormwater management program, various stormwater projects and associated costs need to be identified.

3. Prior to selecting a stormwater utility as a means of financing, other methods of financing should be investigated. The City should establish objectives of the ideal financing method for accomplishing the goals of the stormwater management program and various funding methods investigated.

4. If a stormwater utility is found to be the most feasible source of funds for the stormwater management program, then the goals of the stormwater utility must be defined. With a dedicated source of revenue for water quality enhancement and flooding problems, stormwater management projects identified in the comprehensive stormwater management program, can be prioritized, budgeted, and scheduled for completion.

5. Effective and fair rate structures must be established for the utility.

The stormwater utility concept could be utilized to coordinate and manage watershed management districts throughout the City of East Providence, develop stormwater management strategies, prioritize and fund capital improvement projects, and implement and enforce the city's stormwater management program.

A funding mechanism such as a stormwater utility is meant to be implemented for the entire city to benefit other watersheds as well. If the City of East Providence adopts this method of financing the goals and objectives of a stormwater management plan, it is recommended that the City first review various stormwater utilities established in similar communities. A brief review of various plans is presented below.

Stormwater utilities have been implemented in various communities throughout the country including Charlotte, North Carolina (pop. 314,000); St. Petersburg, Florida (pop. 237,000); Bellevue, Washington (pop. 74,000); and, Forest Park, Ohio (pop. 20,000). Various aspects of these stormwater utilities are summarized below.

City of Charlotte, North Carolina

As part of a comprehensive stormwater management program, the City of Charlotte created a formal public education program to: 1) inform the public about the EPA's NPDES permit application process and requirements and the need for a comprehensive stormwater management program, 2) inform them about the financing mechanisms required for the stormwater management program, and 3) provide a means for handling developers, industries, and various environmental and political groups.

City of St. Petersburg, Florida

The City of St. Petersburg adopted a stormwater utility in 1989 to finance stormwater management projects. The first step was identifying the problem and developing drainage projects and estimated costs. The city conducted several workshops to discuss the problems of stormwater management and to establish objectives for selecting a funding source for the drainage projects. After lengthy review and evaluation of the problems and various funding methods and sources, the St. Petersburg City Council adopted the stormwater utility. The city reviewed numerous existing stormwater utilities before choosing one which served as a model. The utility fee is based on a property owner's contribution to the stormwater management problem.

Bellevue, Washington

The establishment of a stormwater utility in Bellevue has provided a stable source of revenue for financing water quality improvement programs throughout this community. The Bellevue Storm and Surface Water (SSW) Utility encompasses not only stormwater runoff but biological quality, aesthetics, and recreational benefits as well. It was formed in 1974 to maintain a hydrologic balance, prevent property damage, and protect water quality.

The Bellevue utility's method of financing is based on the percentage of imperviousness of a property's total surface area. Although the utility concept was originally not accepted by the community, the public approved the utility's rate structure following the implementation of a public education program focusing on financing alternatives and benefits to water quality enhancement.

Forest Park, Ohio

This small community has successfully implemented a stormwater management program funded by revenues collected through a stormwater utility. The utility was created after first evaluating and documenting the needs of the community, coordinated with a task force composed of local businesses and government. A stormwater management plan was also developed which included financial projections of rate structure, needed capital improvements, and maintenance costs. The startup operations of the utility included immediate implementation of some high visibility projects to demonstrate the utility's effectiveness in controlling stormwater runoff and water quality enhancement.

iii. National Pollutant Discharge Elimination System (NPDES):

Amendments to the Federal Water Pollution Control Act, passed in 1972 and more commonly referred to as the Clean Water Act (CWA), provide that the discharge of pollutants to navigable waters of the United States from a point source is unlawful except in accordance with the National Pollutant Discharge Elimination System (NPDES) permit. Runoff from urban and industrial areas are nonpoint sources of pollution, however, this type of runoff is frequently discharged to a waterway through a conveyance system such as a separate storm sewer. Therefore, this type of runoff is subject to the NPDES program.

The Water Quality Act (WQA) of 1987 is an amendment to the CWA. The central provision of the WQA was to add Section 402(p) to the CWA. This section established the permit application requirements, issuance deadlines, and compliance conditions for different categories of stormwater discharges including industrial activities and large and medium municipal separate stormwater systems.

Municipal Separate Stormwater Systems

Phase I of Section 402(p) of the Water Quality Act of 1987 required the Environmental Protection Agency (EPA) to establish requirements pertaining to stormwater discharges associated with industrial activity, large municipal separate stormwater systems (systems serving a population of 250,000 or more), and medium municipal separate stormwater systems (systems serving a population between 100,000 and 250,000). However, it is anticipated that under Phase II of the NPDES permit program, municipalities that own or operate separate stormwater systems with a population between 50,000 and 100,000 will be required to complete the NPDES permit process. Based on 1990 census statistics, the City of East Providence (population 50,380) would be included within this next phase. Phase II is tentatively scheduled to be implemented by October, 1994.

Part 1 requires reviewing existing stormwater drainage system records and identifying each component (conduits, pipes, catch basins, drainage swales, channels, culverts, etc.) in each subwatershed. Part 2 includes obtaining information to supplement the identification of the sources from Part 1 and developing information to characterize discharges from the municipal system. The mean per capita costs for the cities and counties required to complete Parts 1 and 2 of the Phase I NPDES application was reported as $1.94. Therefore, based on the City's 1990 population, East Providence's NPDES application costs would be almost $100,000. ("NPDES Requirements For Municipal Separate Storm Sewer Systems: Costs and Concerns"; Public Works, January 1993.)

The experience of other municipalities applying for the NPDES permit under Phase I should be drawn upon to help the City of East Providence plan and budget its potential Phase II NPDES permit application process. Therefore, the City should plan for the possibility of having to develop the NPDES program data and information which is required for the permit application.

In addition, stormwater runoff covered under Phase II may be subject to Coastal Nonpoint Source Pollution Control Program requirements. Runoff from wholesale, retail, service, or commercial activities, including gas stations, and construction activities on sites less than 5 acres, all of which are not subject to Phase I of the NPDES program, would be subject instead to a State's Coastal Nonpoint Pollution Control Program. All communities within the Runnins River watershed may eventually be subject to the requirements of this program.

Industrial & Construction Activities

Section 402(p) of the Water Quality Act of 1987 requires owners or operators of specific categories of industrial facilities, which discharge stormwater directly to the waters of the United States or indirectly through a separate storm sewer system, via a point source conveyance, to obtain a NPDES stormwater permit. A point source is defined as "any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel, or other floating craft, from which pollutants are or may be discharged."

Stormwater discharges associated with industrial activity means the discharge from any conveyance which is used for collecting and conveying stormwater and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant.

The EPA has authorized Rhode Island to issue individual or general permits under the Rhode Island Pollution Discharge Elimination System (RIPDES) to cover discharges of industrial activities and construction activities which disturb five acres or more of land. The Rhode Island Department of Environmental Management (RIDEM) is required to update the RIPDES regulations when changes are made to the NPDES regulations and RIDEM's Division of Water Resources is delegated to issue permits for industrial and construction activities.

Construction activities disturbing five or more acres of land and industrial discharges of storm water must apply for a state wide general permit.

A number of industrial facilities within East Providence have applied for a general permit. A summary list of those facilities whose receiving water is within the Runnins River watershed was obtained through researching RIDEM's files.

TABLE 11
EAST PROVIDENCE STORMWATER PERMITS

Name of Facility (As Listed On Permit)	Address	Receiving Water
Precision Art Coord., Inc.	22 Almeida Avenue	Unnamed stream/East Prov. storm sewer to Narragansett Bay
Consolidated Freightways, Inc.	155 Amaral Street	Runnins River

Both of these facilities are adjacent to tributaries of the Runnins River. These are only two specific industries which have applied for a general permit, however, there may be others which are contributing runoff to either the stormwater or sanitary sewer systems. Previous studies in other urban areas have revealed substantial amounts of outfalls exhibiting dry weather flow from illicit connections to the storm drain system. Therefore, the City of East Providence should check their storm sewer systems for illicit connections, particularly from industrial sources.

iv. Erosion & Sediment Control:

The City of East Providence should adopt and implement the Rhode Island Soil Erosion and Sediment Control Act. According to the "Hidden River" report, Section 15-97 of the zoning ordinance offers only limited controls for erosion and sediment control. These regulations require that topsoil be stockpiled and replaced or redistributed on each lot after construction. According to recommendations developed by the Department of Environmental Management, Division of Water Resources, which pertain to stormwater runoff, "...A very important step towns and municipalities can take to substantially reduce soil erosion and sediment loads to receiving waters is the adoption and effective implementation of the Rhode Island Soil Erosion and Sediment Control (SE&SC) Act (RIGL 45-46)." The act is primarily aimed at construction activities and RIDEM also recommends the active enforcement of the

act. The various regulations must be enforced at the local level or contractors at construction sites may not properly install or maintain soil erosion practices. The Rhode Island Soil Erosion and Sediment Control Handbook should be used as guidance for installing and maintaining proper erosion and sediment control techniques at new construction sites.

v. Zoning Ordinances and Land Use Regulations:

The Comprehensive Plan is a guidance and policy document which provides the framework for planned development within a community. Zoning ordinances provide the layout for the location and type of land use activity within a community. Land use is therefore regulated through the use of zoning ordinances. However, presently zoned areas are not always consistent with future needs. (For example, industrial zones over aquifer recharge areas.) Therefore, a community should update present zoning configurations in regards to the goals and objectives of a stormwater management plan.

Zoning ordinances are capable of protecting water resources from adverse water quality impacts within the watershed. If the vacant land remaining in the watershed (70 acres) is developed, it should be done so in accordance with sound stormwater management goals. Zoning restrictions can prohibit or restrict the location of land uses generating pollutants within a zoned area such as: allowing development only in densities which will not exceed the infiltration capacity of the soil; setbacks limiting the conversion of natural ground cover to impervious surfaces; and, buffers around wetlands to limit encroachment. Overlay zones can also be used to impose specific requirements to protect sensitive natural resources (e.g., wetlands) within existing zoning districts. The city presently uses overlay districts for special flood hazard areas and cluster residential developments.

Article VIII of East Providence's zoning ordinance is a Development Plan Review (DPR). The purpose of the DPR is to enable the city to perform a comprehensive review of certain proposed developments to assure safe and orderly development of a site. The DPR includes design standards for minimizing the impacts of stormwater runoff, protecting the surface and groundwater quality, and promoting effective flood management. This is accomplished through landscaping to minimize erosion and providing buffers to minimize stormwater impacts on flood management and water quality. Section 19-455 of the DPR also provides standards specifically for drainage and erosion. The purpose of this section is to promote effective control of erosion and stormwater runoff. There are eleven specific

drainage standards, including "stormwater management" which requires that developments be constructed and maintained such that adjacent and downstream properties are not adversely impacted by stormwater runoff. However, there are no specific standards for erosion and sedimentation other than a statement that "soil erosion and sediment runoff shall be adequately controlled during and after construction" and shall not produce adverse impacts to adjacent properties.

Subdivision regulations are used to prevent haphazard development and as a guide for development to occur on suitable land. According to information contained in the "Hidden River" report, there are limited erosion and sediment controls within the subdivision regulations. These regulations stipulate topsoil to be replaced or redistributed after construction.

B. Source Controls

Source controls emphasize the prevention and reduction of non-point source pollution and excess runoff before it reaches a stormwater collection system or receiving water.

Source controls are frequently used in developed areas because they do not require retrofitting existing stormwater controls which can be more costly. Source controls can be more cost effective due to their relative ease of implementation, especially in urban areas. Source controls include practices which prevent inappropriate discharges to a stormwater collection system and methods of reducing the amount of pollutants which accumulate on the land surface of a watershed.

i. Solid Waste Management:

The water quality problems within the Runnins River have not identified floating or submerged debris and litter as significant problems. A solid waste management program for a community is usually considered when street litter and visible floating debris is a significant source of pollution within a receiving water. Therefore, this method of control was not investigated any further.

ii. Street Sweeping & Catchbasin Cleaning:

The purpose of street sweeping as a method of stormwater management is to reduce pollutant loadings and "first-flush" effects. Although it prevents debris buildup in catchbasins allowing increased flow to the storm drain system, both mechanical and vacuum type sweepers are relatively ineffective at removing fine particles. The results of the National Urban Runoff Program (NURP) state that "street sweeping is generally ineffective as a technique for improving the quality of urban runoff." This is due to the sweeper's ability to remove only larger particles and debris. Pollutants in stormwater are frequently associated with smaller particle sizes, therefore, street sweeping alone is not an effective tool for providing significant improvements in stormwater quality. The effectiveness of street sweeping is further reduced when vehicles are parked in the sweeper's path near the curb or gutter where debris and stormwater pollutants concentrate.

Although vacuuming and sweeping are not effective pollutant removal techniques, they do remove sediment and debris which can clog certain best management practices. For example, pavement vacuuming is required maintenance for porous pavement. Vacuuming removes particles which could cause clogging of the medium used for porous pavement. Current maintenance recommendations call for the porous pavement to be vacuum cleaned at least twice per year under normal circumstances.

Catchbasin cleaning can be used as a method for reducing sediment and debris within stormwater management facilities and receiving waters. A regular maintenance and cleaning program removes the accumulated sediments. It has been documented that this practice can remove as much as 50% of the total suspended solids entering the storm drain system. At present, East Providence has no routine catchbasin cleaning program. However, when they are cleaned, the sediment and debris is disposed of at the Forbes Street landfill.

iii. Soil Erosion Control:

For those areas contributing increased sediment loadings such as at construction sites, a sediment and erosion control strategy should be implemented. As previously stated, the City of East Providence should adopt and implement the Rhode Island Soil Erosion and Sediment Control Act. The Rhode Island Soil Erosion and Sediment Control Handbook should also be used as guidance for installing and maintaining proper erosion and sediment control techniques at new construction sites.

iv. Deicing/Snow Removal Management:

Limiting the use of chemicals and sand for deicing roads helps reduce the amount which accumulates in catch basins and receiving waters. This includes areas sensitive to sediment clogging, such as near stormwater infiltration devices including swales, drywells, and wetlands. Proper control of rates of application are also necessary, particularly near wetlands. The proper on-site storage of these materials (e.g., covering salt storage piles) is required to prevent runoff from the site from entering a storm drain system or receiving water.

v. Fertilizer and Pesticide Control:

Due to the nature of the Runnins River watershed, this strategy, if adopted, would be primarily aimed at homeowners and municipal and private lands such as golf courses. Educating homeowners and other primary users of fertilizers and pesticides in their proper use and disposal, encouraging alternative low maintenance types of turf, and reducing their usage can all lead to reductions of nitrogen and phosphorous. Large amounts of fertilizer and pesticides are applied to home lawns each year. Lawn fertilizers can be significant contributors of nutrients and can stimulate eutrophication in surface waters. Lawn care education seminars have been implemented by the Pokanoket Watershed Alliance in Seekonk and similar seminars may be helpful in East Providence.

vi. Inspecting & Identifying Storm Drain Systems for Non-Stormwater Entries:

Dry weather flows from non-stormwater entries can contribute significant pollutant loadings to a receiving water. Previous studies conducted in urban areas have identified significant dry weather flows resulting from illicit connections to storm drainage systems. If only wet weather flows are considered as a pollutant source in a stormwater management program, and dry weather flows and their sources are ignored, there may not be significant improvements in water quality. Therefore, this should be considered as part of a comprehensive stormwater management program and a methodology for identifying inappropriate entries into storm drain systems is presented here. Potential discharges of dry weather flow originate from residential and commercial sources (e.g., sanitary wastewater, irrigation, car washes, laundry wastewater), industrial sources (e.g., cooling water, process wastewater), intermittent sources such as accidental spills, inadvertent direct connections to

storm drains, and infiltrating groundwater, potable water, or sanitary wastewater from failing septic systems. A methodology for identifying non-stormwater entries is outlined below.

1. Preliminary Watershed Evaluation
   - Locate all outfalls and associated drainage areas.
   - Compile land use data for each drainage area.

2. Select Tracer Parameters
   - Select physical and chemical parameters to measure.
   - Determine number of sampling sites & analysis techniques.
   - Develop potential source flow characteristics.

3. Initial Field Screening Sampling Activities
   - Conduct outfall survey for intermittent and continuous flows.

4. Data Analysis To Identify Problem Outfalls

5. Surveys To Confirm & Locate Inappropriate Entries to the Storm Drain System

6. Identify Corrective Techniques
   - Present stormwater management control strategies.
   - Provide implementation procedure of control strategy.

Source: Investigation of Inappropriate Pollutant Entries Into Storm Drainage Systems: A User's Guide, January 1993; EPA

A gross determination of inappropriate pollutant entries from dry-weather flows and pollutant sources relative to land use will aid in ranking and prioritizing the various sub-watersheds for stormwater management controls. Inspecting the storm drain system for dry-weather flows and locating non-stormwater entries can yield a significant reduction of inappropriate storm drain entries and possible increased receiving water quality. The final report of the NURP study states that "...The costs and complications of locating and eliminating such connections may pose a substantial problem in urban areas, but the opportunities for dramatic improvement in the quality of urban stormwater discharges

certainly exists where this can be accomplished...this BMP is clearly a desirable one to pursue."

C. Infiltration Methods

Infiltration practices are effective at providing storage capacity for excess runoff and at removing certain pollutants by filtering them through the surrounding soil. They require being situated in areas where the local soil and groundwater conditions are suitable for infiltration. The use of infiltration devices is very site-specific and should include careful consideration during the planning stages of any project.

Some advantages of infiltration methods include: reduced pollutant transport to receiving waters; smaller storm sewers required; and reduction of downstream peak flows. Disadvantages of infiltration methods include: required maintenance to reduce clogging by sediments; need to be properly situated within soils capable of discharging runoff; and soils may seal or clog over time.

Below are descriptions of various infiltration methods. Infiltration methods, are typically capable of removing suspended sediments, total phosphorous and nitrogen, oxygen demand, trace metals, and bacteria. Approximate ranges of pollutant removal obtained from Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs are provided, where available. General requirements for infiltration practices are given in the Rhode Island Stormwater Design and Installation Standard Manual. A Current Assessment of Urban Best Management Practices prepared by the Metropolitan Washington Council of Governments in March, 1992 concluded that the longetivity of certain infiltration practices may be severely limited. In particular, the longetivity of trenches, basins, and porous pavement can be severely affected by a number of factors. These factors include the lack of pretreatment (sediment removal), poor construction practices, application of the method to infeasible sites, lack of maintenance, and poor design.

i. Infiltration Trenches & Basins:

Infiltration trenches (Figure 4) are excavated trenches with coarse stone aggregate material and are designed to provide storage of runoff while it is released into the surrounding soil profile. They reduce on-site runoff volumes with few of the surface area

requirements common to other stormwater management practices. They are suitable for small drainage areas of five acres or less and it is recommended that a 20' buffer strip surround the trench. Trenches are extremely adaptable to various sites due to their thin profile. They have a number of applications, including placement around the perimeter of parking lots.

Infiltration basins (Figure 5) are water impoundments created by a dam or embankment construction in a permeable soil. They are generally capable of treating runoff from drainage watersheds of 2 to 15 acres and require large surface areas.

Properly designed, constructed and maintained infiltration trenches and basins can effectively provide water quality control by removing soluble and particulate pollutants. Estimated long-term pollutant removal rates for a full exfiltration system of an infiltration trench exceed 60% of the sediment load, BOD, and bacteria, 40% of trace metals, and 40 to 80% of total phosphorous and nitrogen. Estimated pollutant removal rates for infiltration basins are similar. These estimates are only an indication of possible removal efficiencies.

Neither trenches nor basins are recommended for soils within hydrologic soil group D. Soils within hydrologic soil group C provide only marginal infiltration rates and should also be avoided in most circumstances. The bottom of infiltration basins are susceptible to clogging over time and will lose their infiltration capacity. Proper maintenance includes the removal of sediment buildup and the design should include a sediment forebay situated at the inlet to trap incoming sediment loads and attenuate runoff velocity.

A recent assessment of infiltration trenches and basins recommends the use of pretreatment systems such as grassed swales with check dams or sump pits to aid in controlling sediment inputs, thus preventing clogging of the system. There is also concern that trenches and basins may not be suitable for areas experiencing long cold winters and freeze/thaw cycles.

ii. <u>Swales & Filter Strips:</u>

Swales are open vegetated ditches typically applied in single family residential areas of low to moderate density where the percentage of impervious cover is relatively small (Figure 6). The vegetation cover provides a non-erosive flow velocity and an opportunity for

some runoff pollutant removal through infiltration. They are suitable for areas with porous soils and where the water table is well below the surface. It is recommended that swales be used in conjunction with other stormwater management techniques. For example, swales can be used to aid in controlling water quality by combining with a storm sewer. A raised lip on a storm sewer inlet retains the "first-flush" of runoff within the swale and allows the remaining stormwater to be conveyed through the drainage system.

Properly designed, constructed and maintained swales are capable of providing a moderate removal of particulate pollutants during small storms. This removal efficiency can be provided when the swale has mild side slopes, a dense cover of erosion resistant grass, sub-soils with a high rate of infiltration consisting of hydrologic soil groups A and B, and check dams are used.

Filter strips (Figure 7) are similar to swales except are designed only to handle sheet flow. They should only serve drainage areas less than five acres. Sheet flow is runoff which flows in a thin, even layer over the surface. Runoff from impervious areas within the drainage area must be evenly distributed over the filter strip. Filter strips should be used to treat non-concentrated flows from residential areas, parking lots, and driveways and are meant to be used in conjunction with other stormwater management strategies. They are especially useful as a buffer for other infiltration devices such as an infiltration trench or surrounding wetlands. Filter strips must be equipped with a level spreading device to provide sheet flow, vegetation to prevent erosion, a uniform slope, and be as long as the contributing drainage area. RIDEM suggests that the use of a filter strip as the sole water quality BMP is permissible only when no other method can be utilized due to site constraints.

Overall pollutant removal capabilities of filter strips in urban areas indicate that high runoff velocity hinders their pollutant removal efficiency. Well designed and maintained swales offer the following pollutant removal efficiencies: 70% for total suspended solids, 30% for total phosphorous, 25% for total nitrogen, and 50 to 90% for various trace metals. Swales appear to be more effective at removing metals and solids than nutrients.

iii. <u>Wet Ponds & Retention Basins:</u>

These ponds or basins (Figure 8) are used to keep the runoff on-site and allow it to infiltrate into the soil. Retention basins or wet ponds store the runoff which is gradually

removed by infiltration and evaporation rather than being discharged to surface waters. They are most suitable in residential and commercial developments larger than ten acres with a reliable source of water.

For well designed and maintained ponds, pollutant removal is generally high over the long-term, depending on the size of the pond and the characteristics of the urban pollutants. Pollutant removal efficiencies are 50-90% for sediments, 30-90% for phosphorous, and 40-80% for soluble nutrients. Moderate to high removal efficiencies of trace metals, coliforms, and organic matter have also been reported. The size of the permanent pool in relation to the contributing drainage area is the greatest pollutant removal influencing factor. To maintain a permanent pool, wet ponds should not be sited in areas containing soils of hydrologic soil groups A and B. Due to their ability to remove nitrogen and phosphorous, wet ponds are particularly suitable for areas experiencing nutrient loadings.

iv. <u>Dry Wells:</u>

Dry wells (Figure 9) are similar to infiltration trenches, but are usually smaller. Also, unlike infiltration trenches, dry wells proposed for individual residential dwellings may be suitable for soils in hydrologic soil group C. Dry wells differ from infiltration trenches through the method of inflow. They accept inflow from both surface infiltration and inflow pipes. Dry wells are an effective on-site solution for reducing runoff volumes from rooftops and driveways at sites less than one acre. However, runoff originating from industrial or commercial buildings with pollution control, heating, cooling or venting equipment may require review and approval from the DEM Underground Injection Control Program. Maintenance is required on a regular basis to remove sediment and debris.

v. <u>Porous Pavement:</u>

Porous pavement (Figure 10) consists of porous bituminous concrete paving material and a high void aggregate base that allows rapid infiltration and temporary storage of runoff. It reduces the quantity of runoff generated from roads and parking lots and provides water quality enhancement of runoff through soil infiltration. Porous pavements are generally used for 1/4 to 10 acre sites.

This practice is generally applicable to automobile parking areas and low volume access roads in areas where the groundwater table and soil conditions are suitable and where

off-site runoff is not significant. Soils from hydrologic soil groups A and B (sand and loam) are recommended. It is also recommended that porous pavement not be used in soils with field verified infiltration rates less than 0.5 inches per hour. The primary pollutant removal capabilities of porous pavement are atmospheric pollutants deposited on the pavement. These are either very fine grained or are soluble and should normally not present any clogging problems. Pollutant removal efficiencies range exceed 40% for suspended sediment, 40% for phosphorous and nitrogen, 60% for BOD and bacteria, and 40% for trace metals.

Porous pavement is sensitive to clogging, especially during snow removal and the application of sand or de-icing chemicals. Maintenance is also required to prevent clogging during and after construction. This can be accomplished through pretreatment of the runoff to remove sediment, grit, and oil by using sand filters, filters strips, and oil separators. Maintenance also includes vacuuming and hosing the pavement surface two to four times a year. Porous pavement sites are usually posted to warn against resurfacing with conventional pavement, using abrasives such as sand for deicing, and parking heavy equipment on it.

vi. Sand Filter

A relatively recent development in infiltration and filter stormwater practices is the use of sand filters to control water quality (See Figures 12 and 13). They treat the first flush of runoff from a site which is diverted to the sand bed. The runoff filters through the sand medium, is collected by an underground pipe network, and is then released to a receiving water. An enhanced sand filter utilizes peat or limestone to improve pollutant removal rates.

Sand filters are used strictly for water quality purposes and can provide significant pollutant removal. Pollutant removal rates have been documented at 85% for sediments, 35% for nitrogen, 40% for fecal coliform, and 50-70% for trace metals. Construction costs of various types of sand filters can be 2 to 3 times greater than the cost of an infiltration trench, but they have lower maintenance and rehabilitation costs than infiltration trenches. Sand filters can be applied to many types of sites including commercial and institutional parking lots, gas stations, and fast food establishments. The predominant requirement is 2 to 4 feet of head differential between the inlet and outlet of the filter bed to provide gravity flow.

Sand filters are very adaptable and require only limited space. For example, the Delaware sand filter shown in Figure 13 is suitable for no more than 5 acres of impervious parking lots. This type of sand filter is particularly suitable for retrofitting existing older parking areas. The first chamber of the system provides settling of sediment particles which would otherwise clog the sand filter. Runoff then enters the second chamber containing the sand medium.

Regular maintenance is essential to the effectiveness of sand filters. They require replacement of the surface sand layer on a relatively frequent basis to prevent clogging of the system. Lack of maintenance and sediment deposition on the surface may lead to chronic clogging problems of the filter. Maintenance items include surface sediment removal, raking, and removal of trash, debris, and leaf litter. However, it should be noted that the performance of sand filters in colder climates and freezing conditions is not yet known.

D. Storage Methods

Storage facilities are a common method for controlling excess stormwater runoff and are not generally used for water quality enhancement, unless designed as part of an overall system that includes stormwater treatment to remove pollutants, or are specifically constructed for extended detention. Existing detention basins may be retrofitted to provide extended detention of stormwater, thereby offering a form of water quality treatment through settlement of solids.

i. Wet Ponds or Retention Basins:

Although these are considered infiltration controls, they also act as storage facilities for runoff. They temporarily store the runoff which is then gradually removed by infiltration and evaporation, rather than being discharged to surface waters. As previously discussed, these are suitable for removing nutrients from runoff.

ii. Detention or Extended Detention Ponds:

Because land requirements for detention ponds may be large, other methods of detention are available. One such method is the use of concrete basins. These have the advantage of utilizing various geometric shapes with vertical walls to conform to various

areas and limit the space and right-of-way required. They can be placed in out of sight locations or underground, making them suitable for urbanized areas with little or no space.

There are two basic configurations for detention facilities: on-line and off-line. On-line facilities route the entire flood hydrograph through the detention pond. They are suitable for areas which can be frequently inundated, such as open space and wetlands. Off-line facilities route only the upper portions of a flood hydrograph into a detention area. Therefore, this configuration is most suitable for areas which are frequently used such as playgrounds and athletic fields. However, this configuration also allows the bypassing of the first-flush which typically contains the greatest proportion of pollutants.

Extended detention basins (Figure 11) are capable of controlling both pollution and flooding problems. Dry extended detention ponds remove pollutants primarily through settling and can achieve moderate to high rates of removal for certain pollutants. Since most stormwater pollutants are attached to suspended solids, the removal of total suspended solids will often provide sufficient pollutant removal. Removal efficiencies for suspended sediments are between 30 and 70%, about 20% for total phosphorous, 20% for nitrogen and BOD, and 40% for metals. Due to the lower removal efficiencies for dry extended detention basins, they appear to be more appropriate for areas where the water quality concern is not related to nutrient loadings (e.g., phosphorous and nitrogen).

The advantage of extended detention is its pollutant removal capabilities and the ability to retrofit existing dry and wet ponds in older urbanized areas. However, disadvantages include moderate to high maintenance requirements and the need to remove sediment. If the removal of dissolved nutrients is desired, wet ponds are recommended.

2. Stormwater Management Program

A. Introduction

The City of East Providence has no specific maintenance program for stormwater facilities such as catchbasins. The Highway and Engineering Divisions have the overall responsibility for flooding problems and drainage improvements are typically planned only in conjunction with major road work. It is also anticipated that East Providence, due to its urban character, probably generates significant quantities of stormwater pollutants, although

neither the quantity nor quality of stormwater runoff has been characterized. It is in the public interest for a local government such as the City of East Providence to provide the authority and guidance encompassed within a comprehensive stormwater management program to prevent stormwater runoff problems. However, before a stormwater management plan can be developed, the characterization of the stormwater runoff originating in the City must be accomplished through wet weather sampling of various storm events.

The recommended approach to stormwater management is a comprehensive watershed plan which would provide the most appropriate strategies and optimum locations necessary to alleviate stormwater problems. A comprehensive approach identifies problems, examines the needs of the watershed, and formulates and implements strategies while still accounting for the development and land use requirements of each community in the watershed. Furthermore, since East Providence and the Runnins River are part of the Narragansett Bay watershed, any stormwater management plan should also conform to criteria and standards applicable to Narragansett Bay.

A successful stormwater management program must be based on a comprehensive approach which assures that the volume, peak discharge rate, and pollutant load leaving a site are no greater in the post-development phase than they were in the pre-development phase. Such a plan provides a means of assigning responsibility for design, construction and maintenance of stormwater control facilities, determining regulations for future land use and development within the watershed, providing for the preservation and enhancement of water quality in the receiving waters, and developing a dedicated source of funding necessary to accomplish these objectives.

The framework for a comprehensive stormwater management program is provided below.

B. Essential Elements/Framework

Essential elements of a successful stormwater management program are described below and include:

i. Statement of authority.
ii. Definition of goals and objectives.

iii. Definition of technical terms.

iv. Description of the proposed stormwater management programs's relationship with previously enacted legislation.

v. Cooperation with adjacent communities.

vi. Plan and permitting review process.

i. Regulatory Authorization:

State legislation authorizing local governments to enact stormwater management regulations is a necessary element of a comprehensive stormwater management program. The program should cite state regulations which delegates authority to a local government for making regulatory decisions. As previously stated, the state's Department of Environmental Management (RIDEM) is developing a stormwater management plan.

ii. Goals & Objectives:

An explanation of the goals and objectives of the program should also be clearly stated. Some common goals include the removal of stormwater from areas that are frequently threatened by flooding, the preservation of wildlife, wetlands, and aesthetic values, the control of erosion and sedimentation, and the protection of water quality. The program's goals should be specific and not stated in general terms. A sample of possible goals for the City of East Providence could be to:

1. coordinate stormwater management activities on a watershed basis, specifically with Seekonk, Massachusetts;

2. implement erosion and sedimentation guidelines and regulations;

3. provide enhanced water quality through the implementation of specific controls strategies (e.g., BMP's) at problem sites. This could include the implementation of specific strategies at city-owned sites (DPW garages, municipal parks, etc.) as a demonstration of the city's commitment to stormwater management;

4. identify and eliminate illicit connections to the city's storm drain system;

5. develop a consistent stormwater sampling program in the event the city is required to apply for an NPDES permit and as a means of monitoring the water quality of the Runnins River; and,

6. provide suitable access to the Runnins River for recreational purposes.

iii. Definition of Terms:

Stormwater management regulations use many technical terms. A large portion of the public subjected to these regulations may not have technical backgrounds. Therefore, defining these terms will lead to a more efficient stormwater management program.

iv. Other Relevant Legislation:

Due to the nature of stormwater management, there may be other state and local legislation concerning erosion and sedimentation, zoning and land use restrictions, and floodplain management which may overlap with a stormwater management program. Therefore, previously enacted relevant legislation should be referenced and/or incorporated into the context of a comprehensive stormwater management program.

v. Cooperation With Other Communities:

This is an essential element for a successful stormwater management program. Stormwater runoff is not limited by the jurisdictions of various municipal boundaries. Therefore, neighboring governments of a watershed must cooperate to avoid adverse impacts of new development and urbanization on water quality and flooding within the watershed. Because the Town of Seekonk, Massachusetts comprises about 71% of the watershed's area and accounts for a significant portion of vacant land subject to new development, the City of East Providence should pursue coordinating stormwater management efforts with Seekonk. The overall water quality of the Runnins River can be significantly improved only through watershed-wide planning efforts involving all communities.

vi. Permits & Plan Review:

The City of East Providence has various procedures to ensure that stormwater generated by new development does not produce adverse effects. This includes the Development Plan Review and various zoning ordinances. These were discussed in a previous section.

vii. Alternatives to On-Site Stormwater Management Methods:

Site-specific stormwater management methods are not always the most effective strategies. Off-site or multiple site controls are alternative methods for obtaining stormwater quantity and quality control throughout a watershed. This type of regional planning can be successful if the local governments within the watershed cooperate on a common stormwater management plan. Furthermore, the government is frequently the only party with the authority, interest, and financial resources which are required for regional or watershed-wide planning strategies.

viii. Design Criteria:

Design criteria used for reviewing specific site plans is an important component of a stormwater management plan. The City of East Providence should formulate a set of design criteria to match the stormwater management program's goals. The City of East Providence could use design criteria established by RIDEM as a guideline towards formulating their own. The design criteria could be used for future development, reviewing site plans, and providing water quality enhancement at specific sites. The design criteria should include:

1. A complete list of appropriate stormwater control methods available to a developer.

2. Performance standards for both older existing facilities and proposed developments.

3. A statement of methods used to evaluate proposed stormwater management methods.

4. Inspection and maintenance considerations.

ix. Inspections/Monitoring:

Inspections of stormwater management facilities and monitoring of stormwater quantity and quality are essential parts of a stormwater management plan. Inspections and monitoring should be performed to ensure that the goals of the plan are being met. Physical inspection identifies any necessary maintenance items which must be resolved, and monitoring will ensure that the performance standards set forth in the design criteria are being met. Water quality monitoring is also a requirement of the NPDES permit process.

Periodic inspections of stormwater drain outfalls during dry-weather periods will help identify inappropriate entries to the storm drain system. Inappropriate entries can produce significant pollutant loadings to receiving waters and must be accounted for in a comprehensive stormwater management program. A methodology for identifying these non-stormwater entries has been previously outlined.

x. Maintenance:

Maintenance of stormwater management facilities is an important aspect of the overall plan. A properly designed and constructed facility will not function properly if it is not adequately maintained. Maintenance may include debris removal and catch basin cleaning or mowing and restoring land cover.

C. Recommendations For Implementation of a Stormwater Management Program

The City of East Providence should first formulate its stormwater goals and objectives for the Runnins River watershed and other portions of the city. This should be consistent with Narragansett Bay stormwater management plans and should account for the possibility of applying for a NPDES permit. Through cooperation and coordination with neighboring communities such as Seekonk, Massachusetts, the City of East Providence can then develop a Runnins River watershed stormwater management program which meets its goals and objectives.

Summarized below are characteristics of successful stormwater management programs obtained through an inventory of stormwater management programs in various communities nationwide. Also included (in parentheses) are appropriate recommendations the City of East Providence should consider for each of these stormwater management program elements.

1. A successful program has well defined goals and purposes. **(These must be established by the City and should be based on existing flooding and water quality problems. An inventory or survey of local residents can be beneficial and would serve to notify the public of the City's intention to develop a stormwater management program.)**

2. Stormwater master plans which are actively used and updated. **(A stormwater master plan needs to be established by the City. This includes an identification and prioritization of potential capital improvement projects. Certain projects should be implemented as soon as possible to provide both immediate stormwater benefits and high visibility for the City's stormwater management program.)**

3. Almost every successful program in a larger urban area has a stormwater utility as the main source of funding. **(Investigate feasibility of a stormwater utility as a possible funding mechanism.)**

4. To aid in overcoming multi-jurisdictional problems, regional entities are established to perform stormwater work. **(Establish a method of coordination. A Runnins River Watershed Management District is one possibility which should be investigated.)**

5. The total stormwater management function is consolidated under one authority. **(Investigate feasibility of a stormwater utility or similar entity to control the various aspects of a comprehensive stormwater program.)**

6. Successful programs exhibit tight control on new development by providing guidance on proper stormwater management. **(This can be accomplished through zoning ordinances and the City's existing Development Plan Review (DPR) process.)**

7. Successful stormwater management programs have a well developed permitting procedure, inspection staff, and design criteria. **(Can be accomplished through DPR process, establishment of a stormwater utility, and adopting standards set forth in RIDEM's Stormwater Design & Installation Standards Manual.)**

8. Capital improvement programs established to deal with priority problems. **(To be identified within the context of a stormwater master plan.)**

9. Many successful programs utilize data collection and automated mapping, including Geographic Information Systems (GIS) for planning purposes. **(The City should investigate the need for such a system. GIS applications to stormwater management are described below.)**

10. Ongoing public relations programs to encourage public support. **(Establish a public relations program aimed specifically at stormwater management issues.)**

Source: "Successful Municipal Stormwater Management: Key Elements", by Andrew J. Reese

Additionally, as part of a comprehensive stormwater management program, the inspection and identification of non-stormwater entries to the City's storm drain system should be accomplished.

D. Application of a Geographic Information System (GIS)

Geographic information systems can be utilized successfully for stormwater management purposes. They have been used to manage municipal stormwater programs for the NPDES permit application process and also for modeling urban nonpoint source pollution. Due to the increase in availability and successful use of GIS for stormwater management, its applicability to stormwater management functions and purposes have been summarized below.

Current GIS technology is capable of supporting the spatial data required for urban stormwater management. GIS has been effectively applied to urban stormwater modeling and management and is capable of preparing, storing, updating, analyzing and displaying data in conjunction with stormwater modeling. GIS has also been utilized for managing stormwater programs under the NPDES requirements. Due to NPDES requirements for the inventory of drainage systems, collection of water quality data, long-term monitoring, and estimation of pollutant loads, GIS capabilities are ideally suited to accomplishing these tasks.

The use of GIS has included mapping an area's geographic characteristics, land use data, and hydrologic soil types while incorporating a runoff calculation model and pollutant loading model. Certain water quality parameters are identified for the analysis and a particular runoff methodology adopted to obtain runoff volumes for subwatersheds. Typical pollutant concentrations can then be correlated with the runoff volumes to develop pollutant loadings for each subwatershed. This data can then be utilized to identify appropriate nonpoint pollution control strategies.

E. Narragansett Bay Stormwater Management

The City of East Providence and Runnins River watershed are located within the larger Narragansett Bay watershed. See Plate 2 - Appendix C. The city should be aware of its role within this larger watershed and the overall goal of reducing nonpoint source pollution loadings originating from the Runnins River watershed.

In 1989 Narragansett Bay was selected as a participant in the EPA's National Estuary Program. As part of this program, a draft of the Narragansett Bay Comprehensive Conservation and Management Plan was completed in January, 1992. Key actions outlined in the plan include updating state regulations for siting, design, construction, and maintenance of onsite sewage disposal systems, guidance for municipal officials on the control of nonpoint source pollution, and development of stormwater management plans.

According to a report produced by the Soil Conservation Service concerning nonpoint source management within the Narragansett Bay watershed, the primary goal is to reduce the loadings of nonpoint source pollutants to the bay. A number of objectives are stated, including: 1) developing and implementing consistent nonpoint source guidance, standards, and practices, including design and performance standards; 2) implementing consistent stormwater management on a watershed basis; 3) improving the assessment and identification of potential nonpoint sources of pollution; 4) improving state and federal regulatory programs concerning nonpoint source management; and, 5) improving the effectiveness of municipal and landuser efforts to implement nonpoint source pollution controls.

Many of these same objectives can be met for the Runnins River watershed through the implementation of the various stormwater management strategies previously outlined. At the very least, coordination with neighboring communities concerning a consistent stormwater management program on a watershed basis would provide the foundation for further work. One method previously outlined is the creation of a watershed management district.

VIII. CONCLUSIONS

Water quality degradation of the Runnins River has been previously documented and is an ongoing concern to the various users and residents of the watershed and downstream receiving waters such as Hundred Acre Cove. However, the sources of these pollutants have not been completely identified. While fecal coliform contamination has been identified as a significant pollutant, and typical sources such as septic systems have been identified in Seekonk, there is no clear indication of the extent of East Providence's contribution to fecal coliform contamination. Since septic systems can be a primary cause of fecal coliform contamination, and the majority of East Providence is sewered, it would appear that areas of the watershed other than East Providence are the primary contributors of fecal coliform. Furthermore, stormwater runoff originating in the East Providence portion of the watershed has not been characterized based on the type and concentration of various pollutants. Therefore, sampling and monitoring of various wet weather events is necessary.

The following conclusions have been identified:

- The existing data, such as that collected by the PWA, is inconclusive for determining specific nonpoint sources of fecal coliform or for apportioning the fecal coliform concentrations to either East Providence or Seekonk.

- Possible sources of fecal coliform contamination originating from East Providence have been qualitatively identified below. These possible sources include:

    1. Approximately 14 residential units and 12 commercial facilities are not presently connected to the sewerage collection system. These facilities are located in the Orange Juice Creek tributary (Amaral Street and Boyd Avenue areas). Dry weather sampling conducted in August 1992 indicated that fecal coliform levels are well below Class B criteria within the Orange Juice Creek tributary. This tributary drains about 25% of the East Providence portion of the Runnins River watershed. Therefore, this may be an indication that septic systems serving these facilities and residences are not a significant source of fecal coliform.

2. Sewage pumping station overflows have been previously documented and are intermittent. They occur only occasionally at one pumping station within the watershed (Pumping Station No. 16, Wannamoisett Road) and are not a major problem.

3. Under certain conditions, areas of excess infiltration into the sewerage collection system could possibly be susceptible to exfiltration. Sections of the sewer system which experience excessive infiltration have already been identified. Therefore, corrective measures taken in these areas would also eliminate the potential for exfiltration to the local groundwater and subsequently the Runnins River.

4. Inappropriate sewer connections to the storm drain system can be identified through an analysis and investigation of dry weather flows at storm drain outfall pipes and manholes. However, for the portion of the City which drains into the Orange Juice Creek tributary, dry weather water quality sampling indicates that fecal coliform contamination is not a problem. This is an indication that cross-connections between the sanitary sewer and the storm drain system does not exist in this subwatershed. Therefore, any investigation of possible inappropriate entries to the storm drain system could be focused on the Cemetery and High School tributary subwatersheds.

5. Fecal coliform from local wildlife is a potential source of contamination. However, the magnitude of this potential source is unknown and could apply equally throughout the Runnins River watershed.

- There are no wet weather sampling results to quantify or identify typical stormwater pollutant concentrations. While it appears that fecal coliform resulting from septic systems may be a primary contributor to the water quality problems of the Runnins River, wet weather monitoring can identify other stormwater contaminants.

- Based on sediment analyses conducted in June 1992, other pollutants affecting the Runnins River include copper, lead, arsenic, zinc and iron. The sources of these contaminants have not been identified. The identification of the type and source of pollutants requires monitoring of both wet and dry weather flows before adopting specific stormwater control strategies.

- While the Runnins River watershed accounts for 70% of the Hundred Acre Cove watershed, its pollutant contribution to Hundred Acre Cove has not been identified. For example, shoreline surveys of the watershed have identified 7 storm drains discharging to the Runnins River from East Providence, 11 from Seekonk, and about 30 into the Hundred Acre Cove area from Barrington. The contribution to water quality degradation from the Barrington storm drains and the effects of tidal flushing and currents on pollutant transport and dispersion patterns within Hundred Acre Cove have also not yet been determined.

- Based on the data and information reviewed in this study and the identification of possible sources of fecal coliform contamination, it is unlikely that East Providence is a significant contributor of fecal coliform. However, sources such as inappropriate entries to the storm drain system and establishments with septic systems should be investigated to definitively eliminate them as possible contributors of fecal coliform contamination. This can be accomplished through stormwater monitoring of outfalls and the inspection and possible dye testing of existing septic systems.

IX. RECOMMENDATIONS

Recommendations for the City of East Providence to consider are given below. They include aspects of the four stormwater control strategies previously discussed, development and implementation of a comprehensive stormwater management program and the accomplishment of specific tasks.

- **Runnins River Watershed Management District**

A commitment from the City of East Providence to provide coordination, cooperation, and communication among the various political entities within the watershed is required. This can be accomplished through the creation of the Runnins River Watershed Management District (RRWMD).

- **Stormwater Utility**

The City should explore various funding mechanisms as a means of financing a comprehensive stormwater management program. The City of East Providence should investigate the feasibility of creating a stormwater utility as a means of funding a city-wide stormwater management program and possible NPDES requirements. It is recommended that if the City of East Providence adopts this method of financing the goals and objectives of a stormwater management program, the City should first review various stormwater utilities established in other communities.

- **NPDES**

In anticipation of complying with Phase II of the NPDES permit application process, the City should identify, inspect, and inventory all sources of sewer, stormwater, and industrial discharges which are typically required for Part 1 of the permit application. Phase II is tentatively scheduled to be implemented in October, 1994. Based on the City's 1990 population, East Providence's NPDES application costs are estimated to be about $100,000.

- **Erosion & Sediment Control**

Adopt and implement the Rhode Island Soil Erosion & Sediment Control Act and use the Rhode Island Soil Erosion and Sediment Control Handbook as guidance for installing and maintaining proper erosion and sediment control techniques at new construction sites.

- **Zoning Ordinances & Land Use Regulations**

The City of East Providence should update present zoning configurations in regard to the goals and objectives of a stormwater management plan. East Providence should also investigate the feasibility of extending the Development Plan Review (DPR) process or a similar process for developments not presently covered under the current DPR. Standards concerning erosion and sediment control should also be included within the DPR. Furthermore, the City should investigate the feasibility of extending the DPR process throughout the watershed to aid in establishing uniform methods of stormwater management. A watershed DPR process could be established under the watershed management district concept and would provide stormwater management guidelines for future development in the watershed.

- **Deicing/Snow Removal Management**

Review use and storage of deicing chemicals and salt in relation to overall stormwater management goals. In particular, any storage piles at the Department of Public Works garage, which is in close proximity to the East Providence High School tributary, should be kept properly covered.

- **Inspecting & Identifying Storm Drain Systems for Non-Stormwater Entries**

Develop and implement a program to periodically inspect and identify non-stormwater entries to East Providence's storm drain system. This task could be implemented and managed within the context of the proposed stormwater utility.

o **Infiltration Methods**

The following methods are meant to be implemented after first identifying particular sites which contribute significant stormwater runoff pollutants. This must be accomplished through wet weather sampling of stormwater runoff. The selection of appropriate stormwater management options is site-specific and depends on many variables including, but not limited to, soil type, size of the drainage area, slope, land use, and the type of pollutants originating from the site. However, preliminary planning can identify certain methods which may be more suitable than others within a particular area. These methods could be required for new development, or considered as retrofits to existing developed areas. Careful planning of any of the following methods is essential, especially because some of the infiltration methods have not yet been proven to be effective in colder climates.

<u>Infiltration Trenches & Basins</u>

These methods may be suitable in residential areas around the former Kent Heights landfill, the residential and commercial area west of Pawtucket Avenue and north of Interstate 195. However, other factors such as slope, topography, geology, and hydraulics must also be considered and this requires further investigation. In the case of the Marsh, Abbott, and State Street area, the groundwater table is shallow (Warren Avenue Drainage Study, 1986) and much of this area is also within the 100-year floodplain (Flood Insurance Rate Map, 1982) at the confluence of the East Providence High School tributary and the Runnins River. Therefore, infiltration methods in this particular vicinity may not be suitable, regardless of soil type. Furthermore, since a stormwater drainage system is already in place to convey runoff from the site, on-site infiltration methods may not provide any further flooding relief. As specified within the Warren Avenue Drainage Study conducted by Keyes Associates in 1986, flooding relief in this area may require either upstream controls on runoff or removal of downstream hydraulic constrictions within the Runnins River such as enlarging or cleaning culverts.

The Catamore Boulevard area which is dominated by light industrial and commercial land usage with large parking areas and soil types from hydrologic soil groups A and B, may also be a suitable area for investigating the use of infiltration trenches and basins inconjunction with other methods such as porous pavement for any low volume parking areas. Infiltration trenches placed between the parking lots and the Runnins River and its

tributary, Orange Juice Creek, may also be useful in reducing certain pollutant concentrations.

Swales & Filter Strips

These would also be useful in areas of hydrologic soil groups A and B and could be used to help reduce sediment input which may clog other BMPs.

Sand Filters

Although the performance of sand filters in colder climates and freezing conditions is not known, it may provide adequate pollutant removal. In particular, the Delaware sand filter, or a similar type, may be a suitable stormwater retrofit for existing parking areas which contribute runoff to the Runnins River or its tributaries.

Wet Ponds & Retention Basins

Although limited primarily by space constraints, there are open areas with suitable soils in the southern portion of the watershed around the Gate of Heaven Cemetery and Mobil Oil. This method is capable of providing high levels of pollutant removal, particularly of nutrients (phosphorous and nitrogen). Therefore, if wet weather sampling indicates that nutrient loading is significant, wet ponds should be investigated further. Further investigation is required before this method could be implemented.

Dry Wells & Porous Pavement

Dry wells are particularly suitable for rooftop drainage and porous pavement is suitable for low volume parking areas. Both should be further investigated for use within the industrial and commercial areas of Amaral Street and Catamore Boulevard. Filter strips may also be used in conjunction with porous pavement to help reduce sediment loads and clogging, although porous pavement should not be receiving runoff from other off-site sources. The use of dry wells and porous pavement depends on soil suitability and other site-specific considerations. The above areas contain light industrial and commercial land use and associated parking areas which typically generate pollutants such as metals and sediments. Nutrients are usually not as much of a concern in light industrial areas. For

example, Orange Juice Creek drains the industrial area along Amaral Street where an automobile salvage yard is located directly adjacent to this tributary. Since this type of establishment does not usually generate high nutrient loads, wet ponds or retention basins are not recommended for this area. Metals and petroleum products are of more concern in areas such as this.

o **Storage Methods**

Selecting appropriate stormwater management strategies requires an analysis of site-specific conditions relating to stormwater quantity and quality.

Detention or Extended Detention Ponds

This method may require substantial space to properly size the detention or extended detention ponds. Since water quality issues are of primary concern within the watershed, the use of "on-line" extended detention ponds may be warranted for areas not experiencing significant nutrient loading.

Choosing stormwater management control strategies for particular sites within East Providence requires detailed analysis of site-specific parameters such as drainage patterns, soil type and pollutant loads. This was not within the scope of this study. Furthermore, obtaining the goal of increased water quality requires an understanding and knowledge of the types and quantities of pollutants both within the Runnins River and originating from within a specific area or subwatershed. This has not yet been completely accomplished.

o **Stormwater Management Program**

The first task is for the City of East Providence to formulate its stormwater goals and objectives. The following tasks will aid in providing the basis to develop a comprehensive stormwater management program, help determine the need for a stormwater utility as part of that program, and provide the immediate benefits of increased public visibility of the City's stormwater management efforts. The stormwater management program and utility concepts can be applied throughout the City of East Providence. As part of the process of developing and funding a comprehensive stormwater management program and/or stormwater utility, the City should undertake a public education and awareness program concerning stormwater

issues throughout the City. In addition, one method to gain awareness and public support is to perform tasks which are both highly visible to the general public or which provide immediate benefits.

Task 1: Survey local residents and businesses regarding flooding and water quality problems throughout the city and inventory specific problem sites.

Task 2: Field inspect storm drain outfalls for dry weather flow and perform subsequent observations of the type of industrial or commercial land use occurring within that area which may be contributing to the dry weather flow through non-stormwater entries to the storm drain system. Considering dry weather flow as a source of pollutants is an integral part of a comprehensive stormwater management program. This should involve inspection of individual sewage disposal systems serving the residential and commercial facilities not presently connected to the City's sewerage collection system. Accomplishing this task will help eliminate inappropriate connections and individual sewage disposal systems as possible sources of fecal coliform pollution.

Task 3: Inventory storm drainage features (e.g., outfalls, catchbasins, manholes, culverts, etc.), and establish and implement a regular catchbasin cleaning program to reduce sediments and debris within the storm drain system.

Task 4: Implement a wet weather sampling program to characterize the types and concentrations of stormwater pollutants originating from the East Providence portion of the watershed.

Task 5: Potential sources of typical nonpoint pollutants can be identified by investigating current specific land uses in each of the various subwatersheds. This can be accomplished by conducting a windshield survey of the various drainage basins. Although this does not account for seasonal variations, soil type, topography, vegetation cover, atmospheric fallout, or population density, it will enable the City to identify obvious sources of surface runoff pollution. Examples include the auto salvage and storage yard adjacent to Orange Juice Creek and numerous parking areas draining to receiving waters.

Task 6: Rank those sources of runoff which will likely contribute to water quality problems. Develop and implement a monitoring plan to characterize pollutants from these sites and within the tributaries. A typical monitoring plan is outlined below.

Task 7: Identify and develop a program of possible stormwater control measures, including their preliminary costs, for these sites. Pilot studies or demonstration projects of best management practices may be a suitable means of determining the optimal or most effective stormwater management methodologies.

These tasks can help the City of East Providence formulate its stormwater goals and objectives and provide immediate visibility to the public of the City's stormwater management efforts. As part of the tasks described above, and as means of characterizing the quality of stormwater originating in East Providence, a monitoring plan outline is presented below.

East Providence Stormwater Monitoring Plan Outline

This stormwater monitoring plan is meant to characterize the physical and chemical parameters of stormwater which originates in East Providence, to supplement the data already collected by other groups or agencies, and as a means of determining nonpoint sources of pollution within the subwatersheds draining East Providence.

It is anticipated that the number of sampling locations will include: the 7 storm drains previously identified by shoreline surveys, 1 sample location for each tributary (3 total), and 2 sampling points within each of the three tributaries (6 total) at either a manhole or subwatershed outfall, for a total of 16 water quality sampling stations.

1. Identify sampling locations for wet and dry weather activities based on land use and existing information. Identify relevant water quality parameters for sampling and measurement (e.g., fecal coliform, temperature, hardness, nitrogen, metals, etc.)
   Estimated Cost = $3,000

2. Field check the potential monitoring sites for ease of obtaining samples and flow measurements.
   Estimated Cost = $1,000

3. Collect and analyze water quality samples during two storm events and during one dry weather period. This includes the installation of a rain gage and measurement of flows. The dry weather samples will aid in identifying inappropriate entries (e.g., illegal connections) to the stormwater drainage system. Estimated Cost = $70,000

The total estimated cost for sampling two wet weather events and one dry weather event is $74,000. This estimated cost depends on available manpower, equipment, sampling methods, and analyzing techniques. For the purpose of the above outline, it is assumed grab samples will be suitable.

X. Acknowledgments

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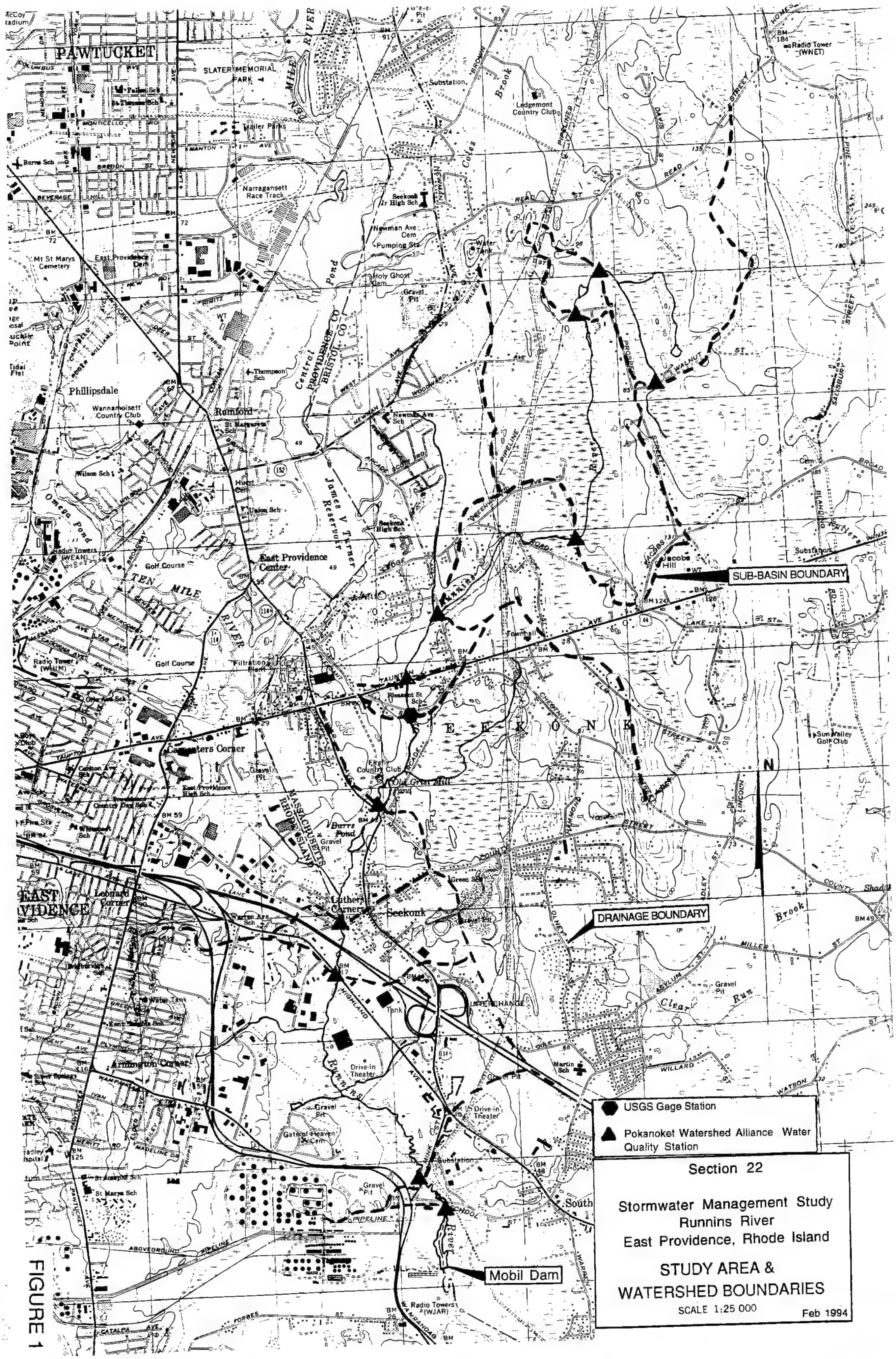
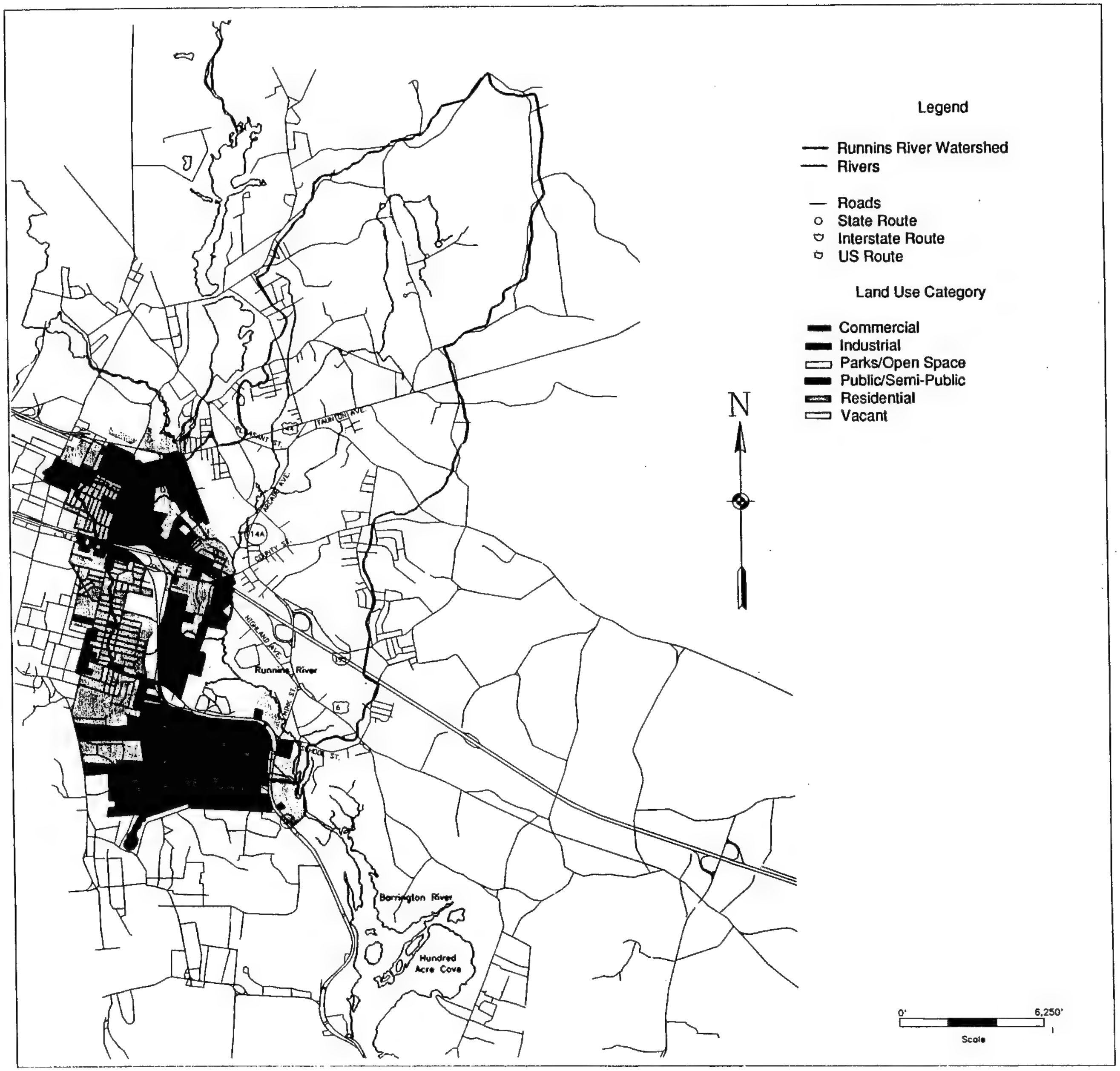

SUB-BASIN BOUNDARY
DRAINAGE BOUNDARY
Mobil Dam
USGS Gage Station
Pokanoket Watershed Alliance Water Quality Station
Section 22
Stormwater Management Study
Runnins River
East Providence, Rhode Island
STUDY AREA &
WATERSHED BOUNDARIES
SCALE 1:25 000
Feb 1994
PAWTUCKET
SEEKONK
East Providence Center
Rumford
Phillipsdale
Seekonk
N

FIGURE 1

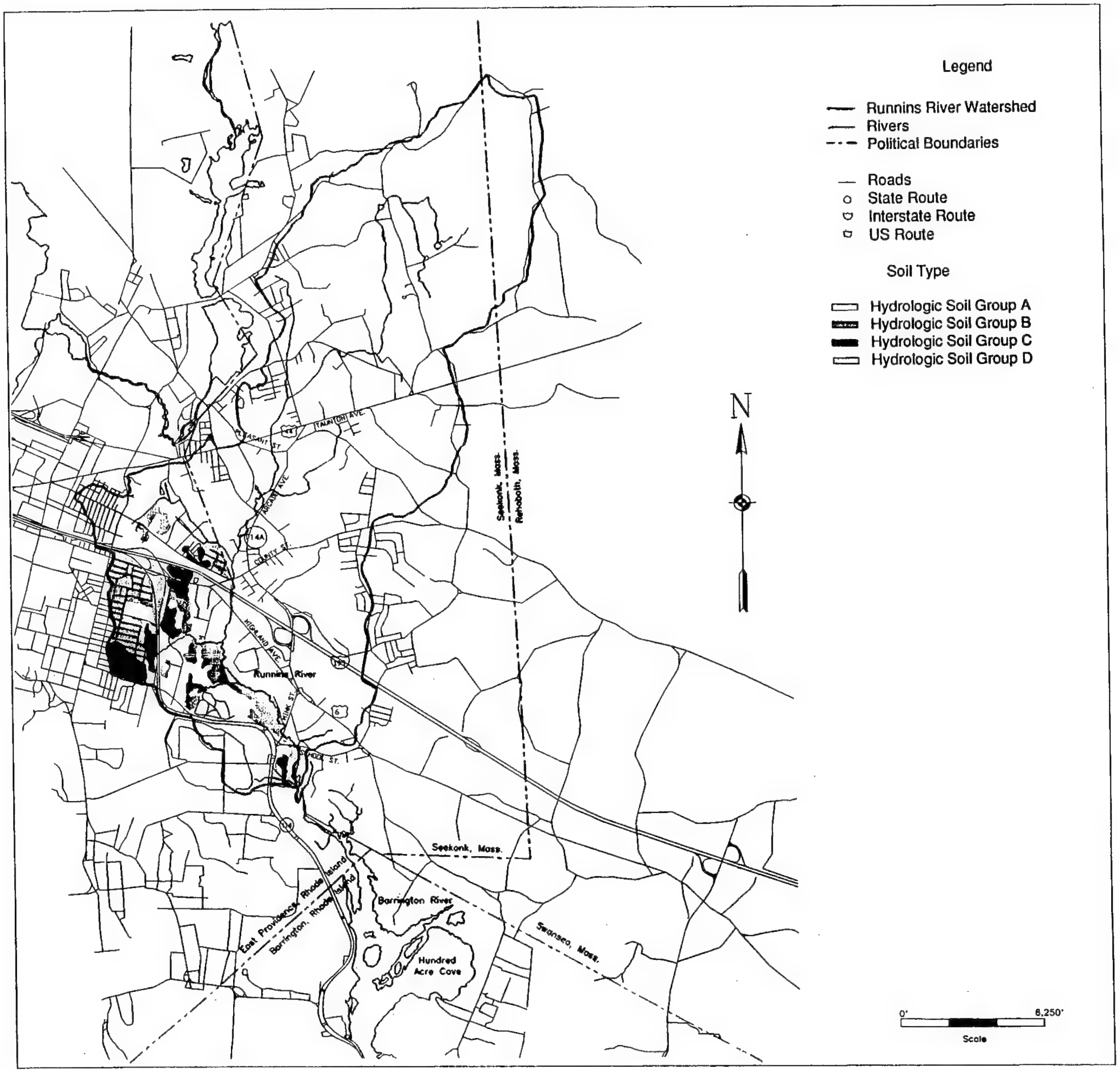


Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

East Providence Land Use

FIGURE 2

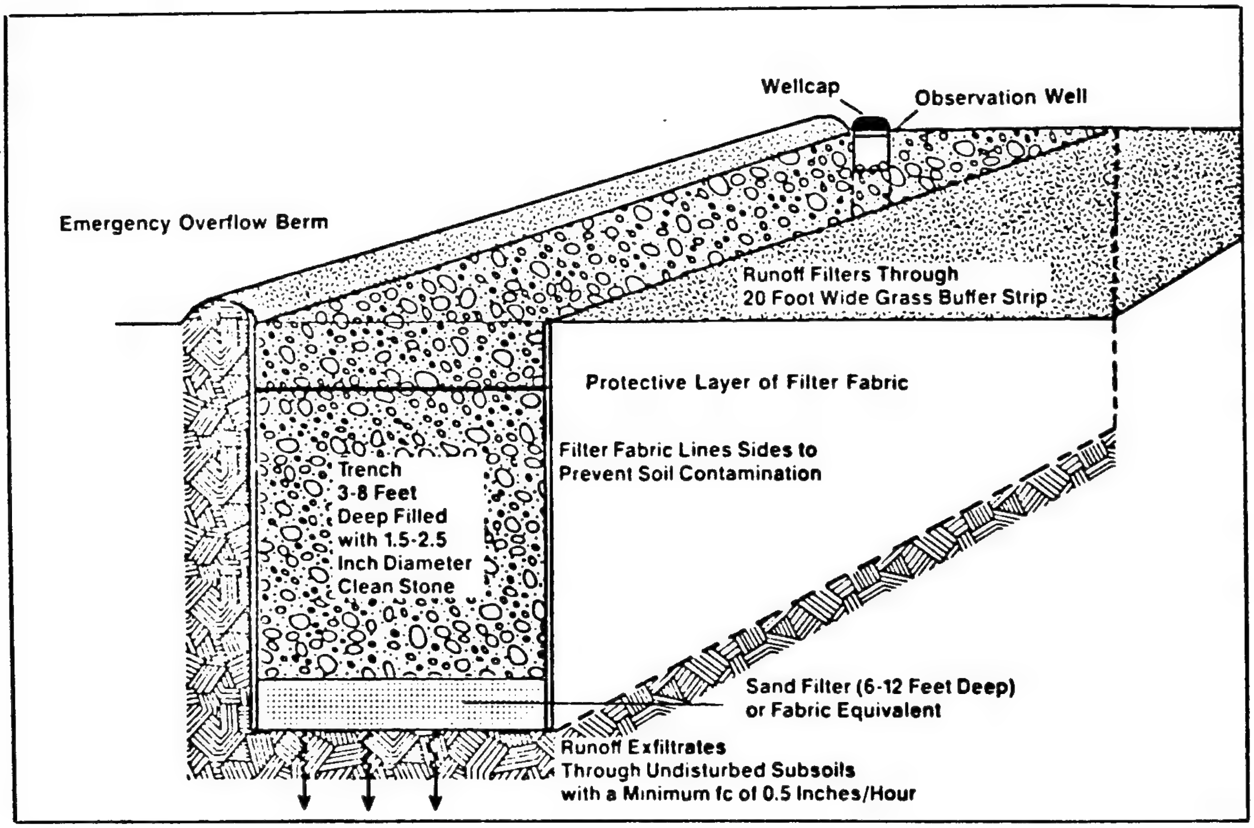


Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

East Providence
Soil Type

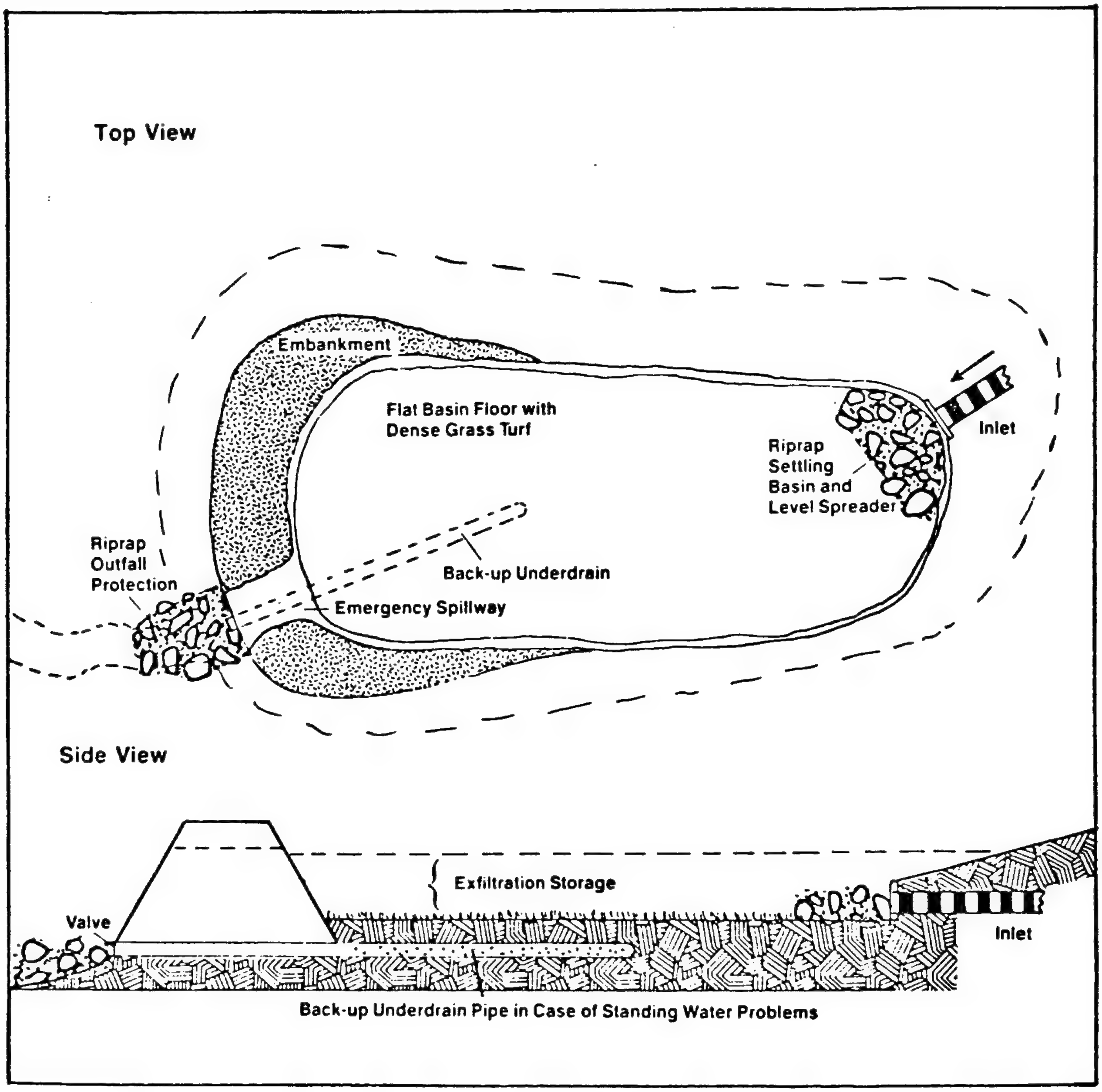
FIGURE 3



(Source: Schueler, T.R., 1987, "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs", Metropolitan Washington Council of Governments)

INFILTRATION TRENCH

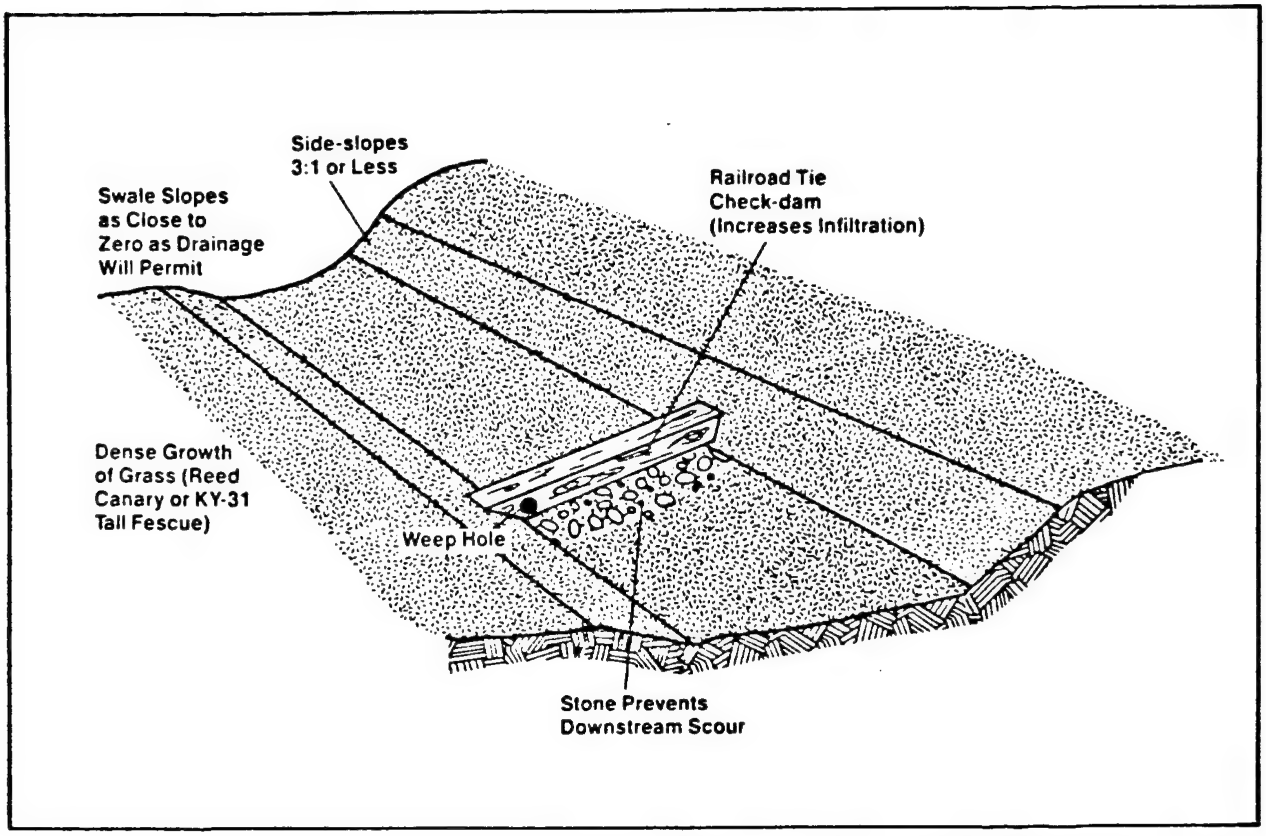
FIGURE 4



(Source: Schueler, T.R., 1987, "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs", Metropolitan Washington Council of Governments)

INFILTRATION BASIN

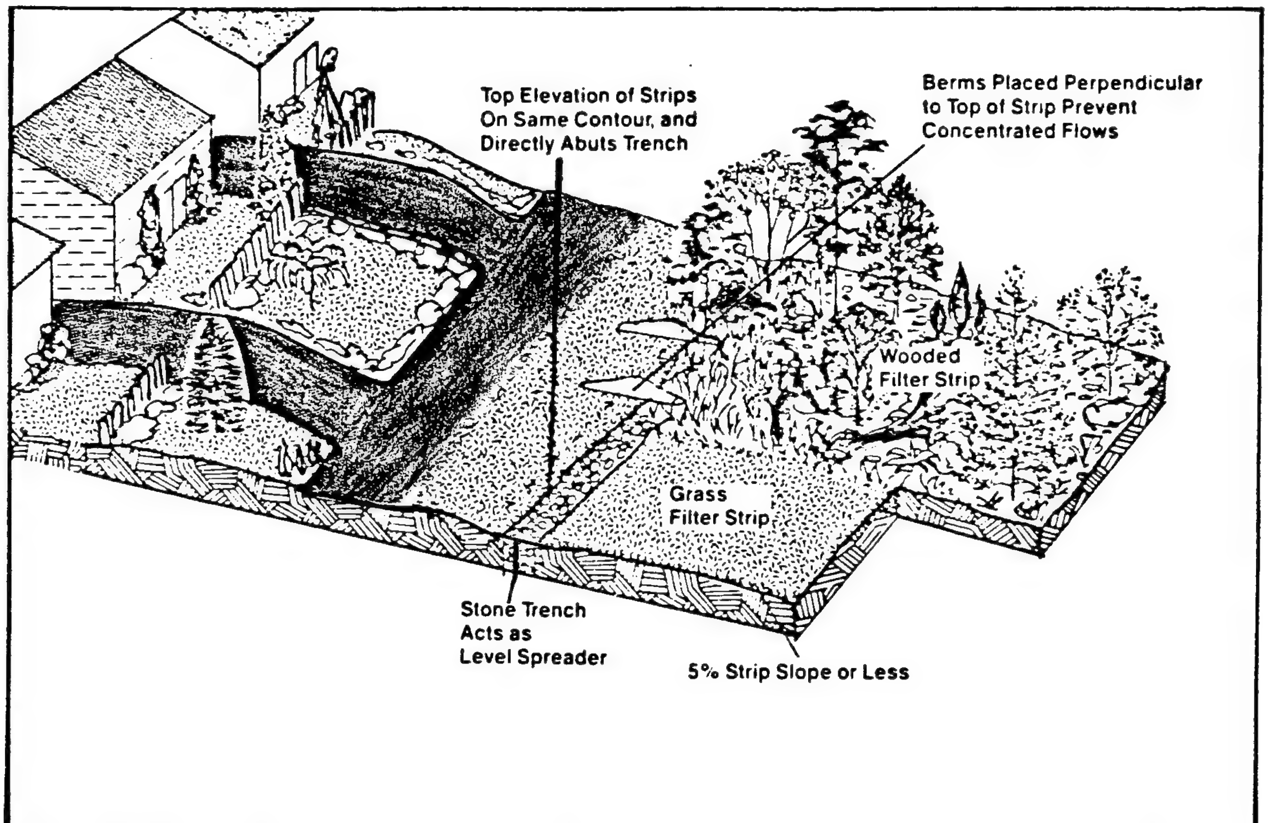
FIGURE 5



(Source: Schueler, T.R., 1987, "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs", Metropolitan Washington Council of Governments)

SWALE

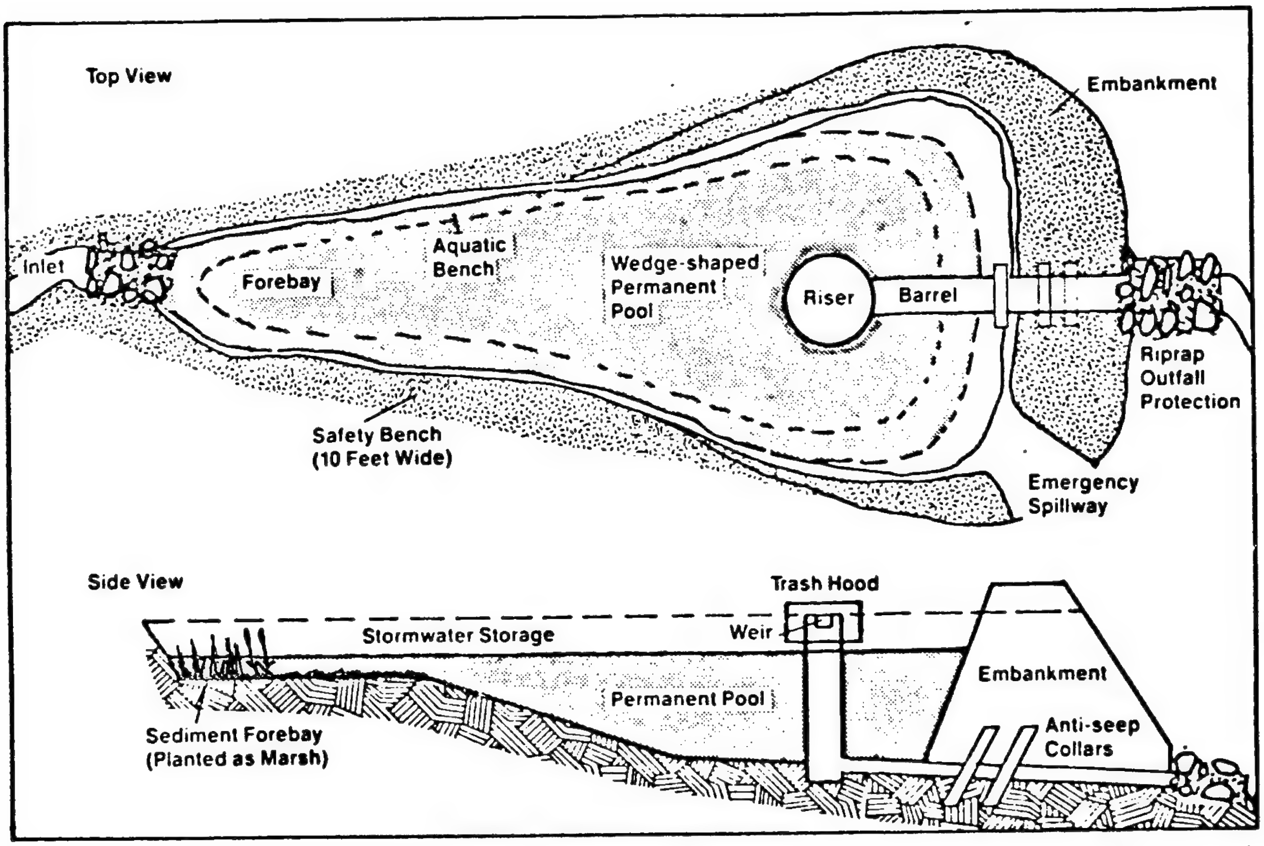
FIGURE 6



(Source: Schueler, T.R., 1987, "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs", Metropolitan Washington Council of Governments)

VEGETATED FILTER/BUFFER STRIPS

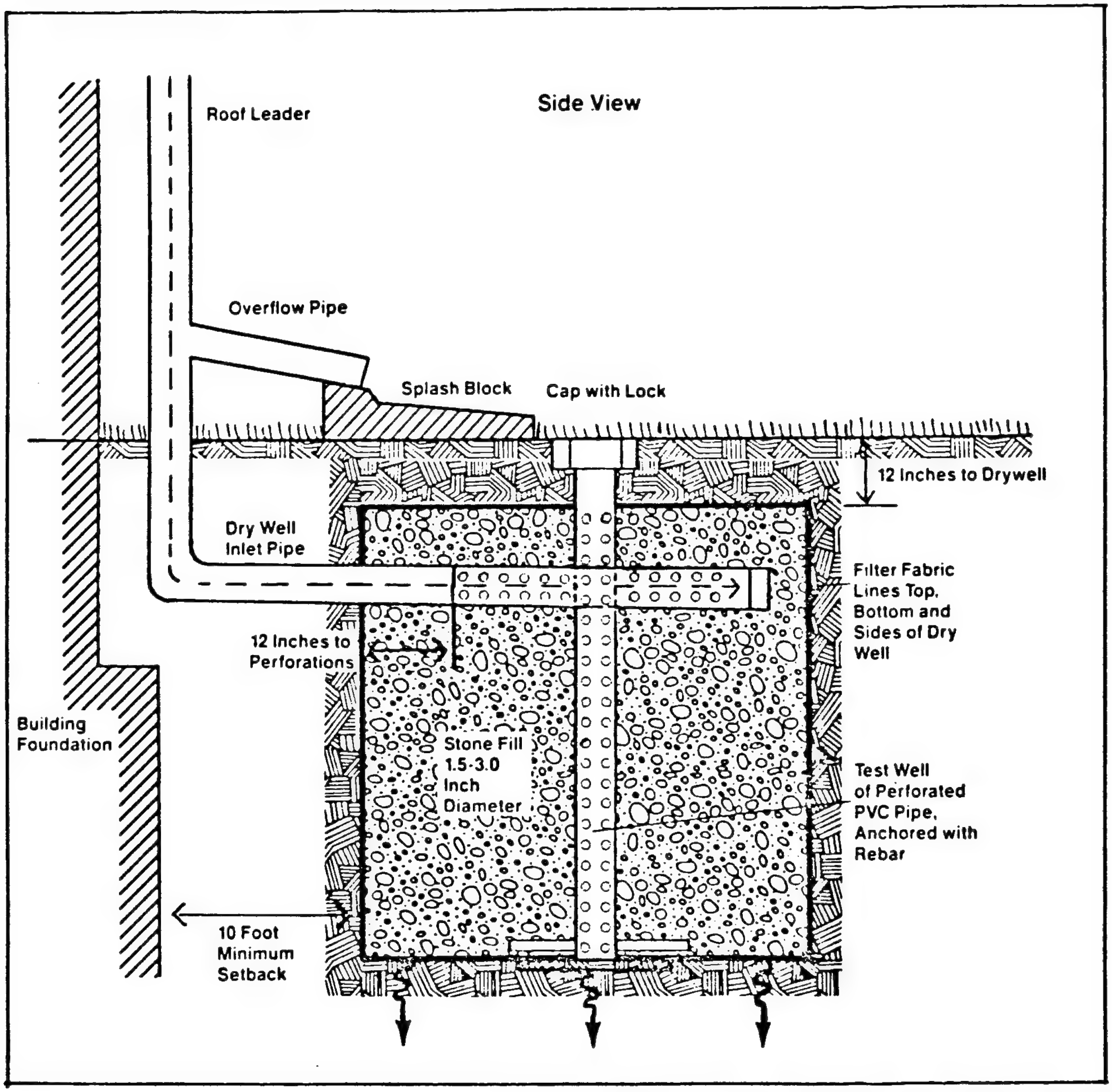
FIGURE 7



(Source: Schueler, T.R., 1987, "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs", Metropolitan Washington Council of Governments)

RETENTION BASIN/WET POND

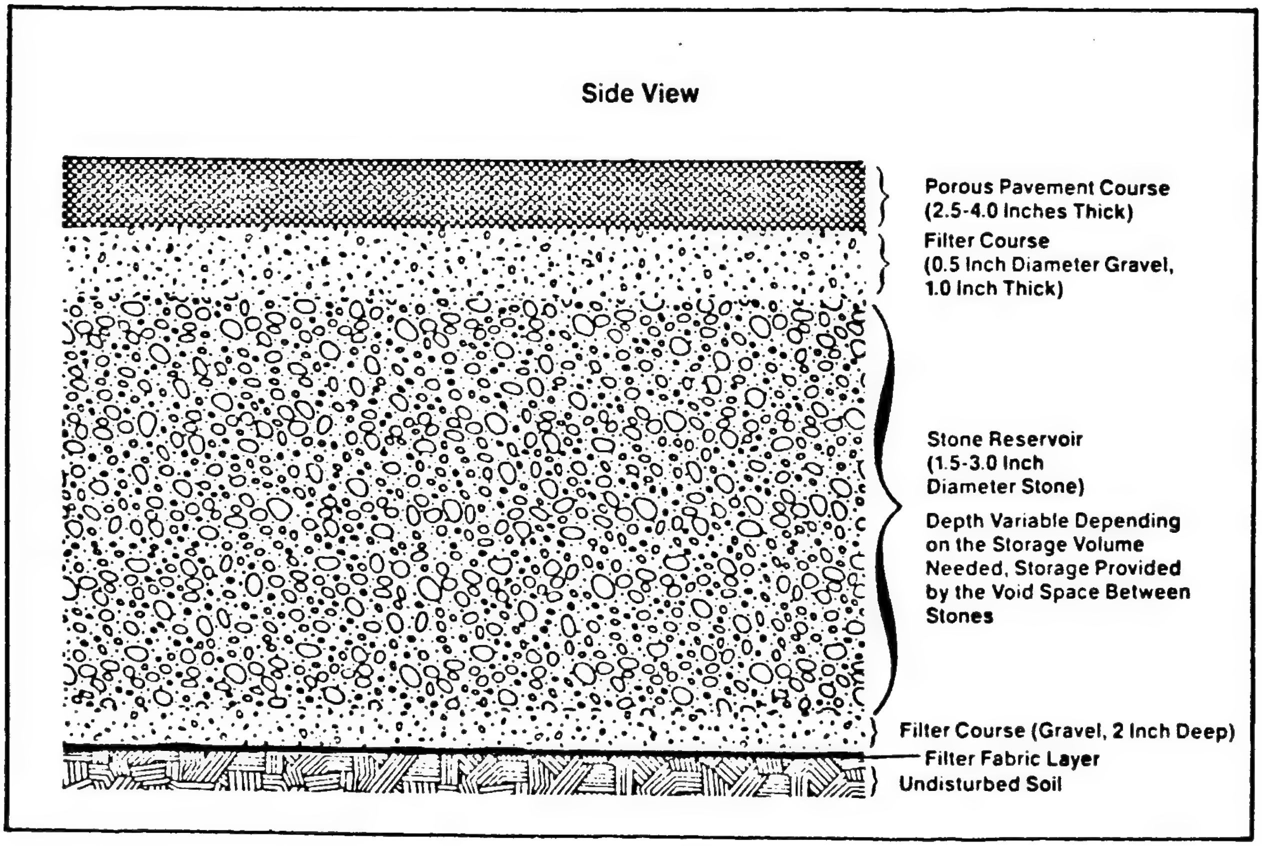
FIGURE 8



(Source: Schueler, T.R., 1987, "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs", Metropolitan Washington Council of Governments)

DRY WELLS

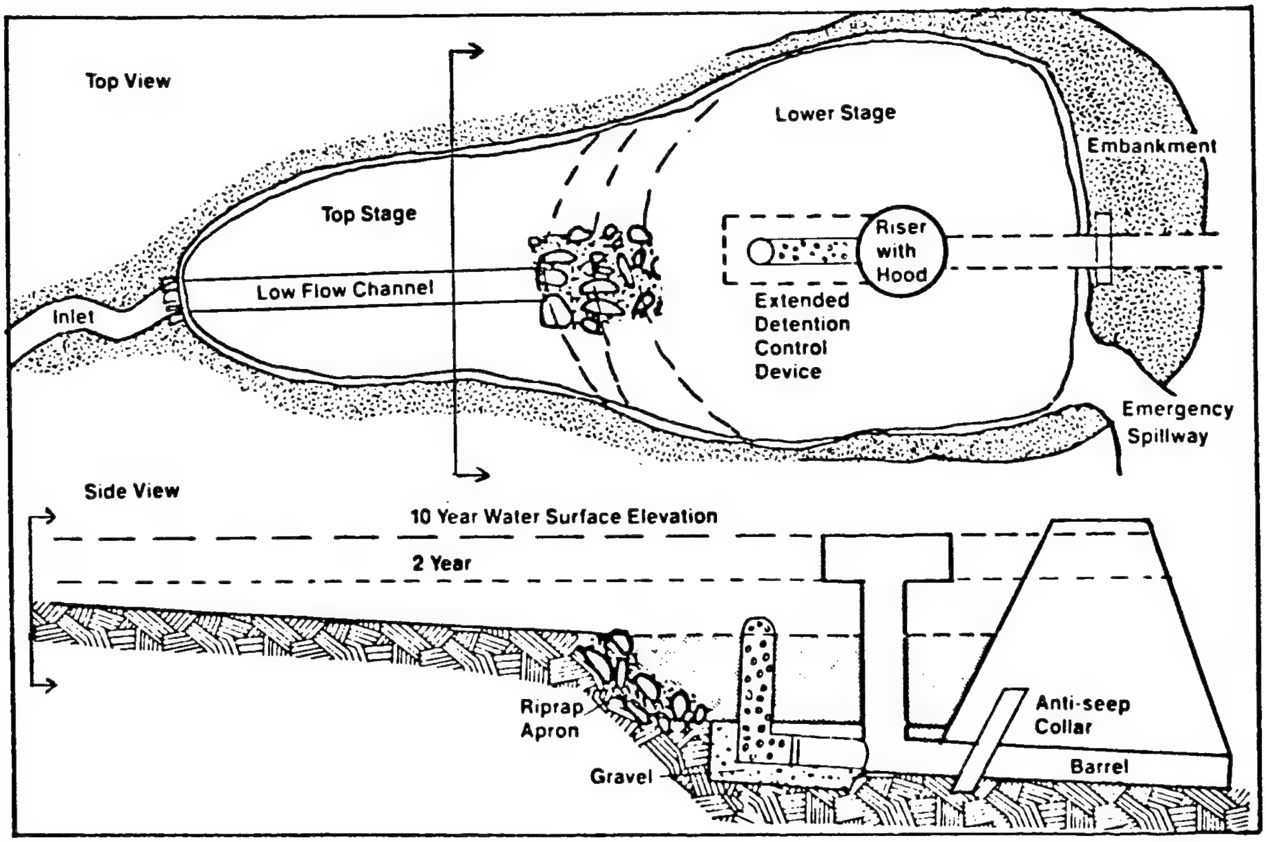
FIGURE 9



(Source: Schueler, T.R., 1987, "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs", Metropolitan Washington Council of Governments)

POROUS PAVEMENT

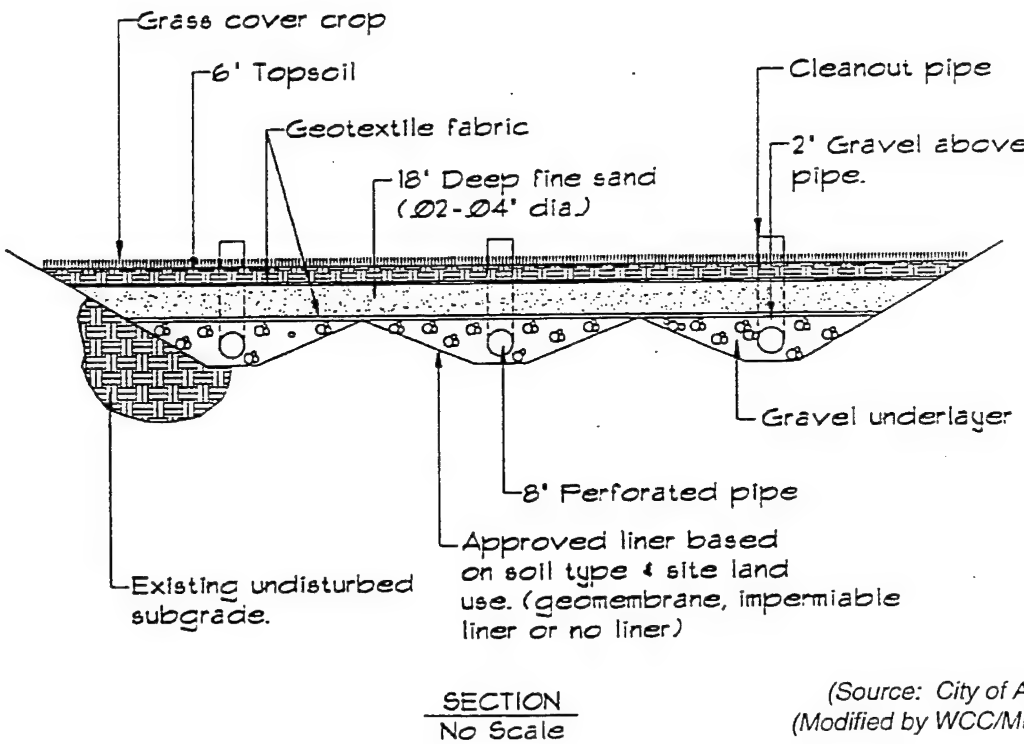
FIGURE 10



(Source: Schueler, T.R., 1987, "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs", Metropolitan Washington Council of Governments)

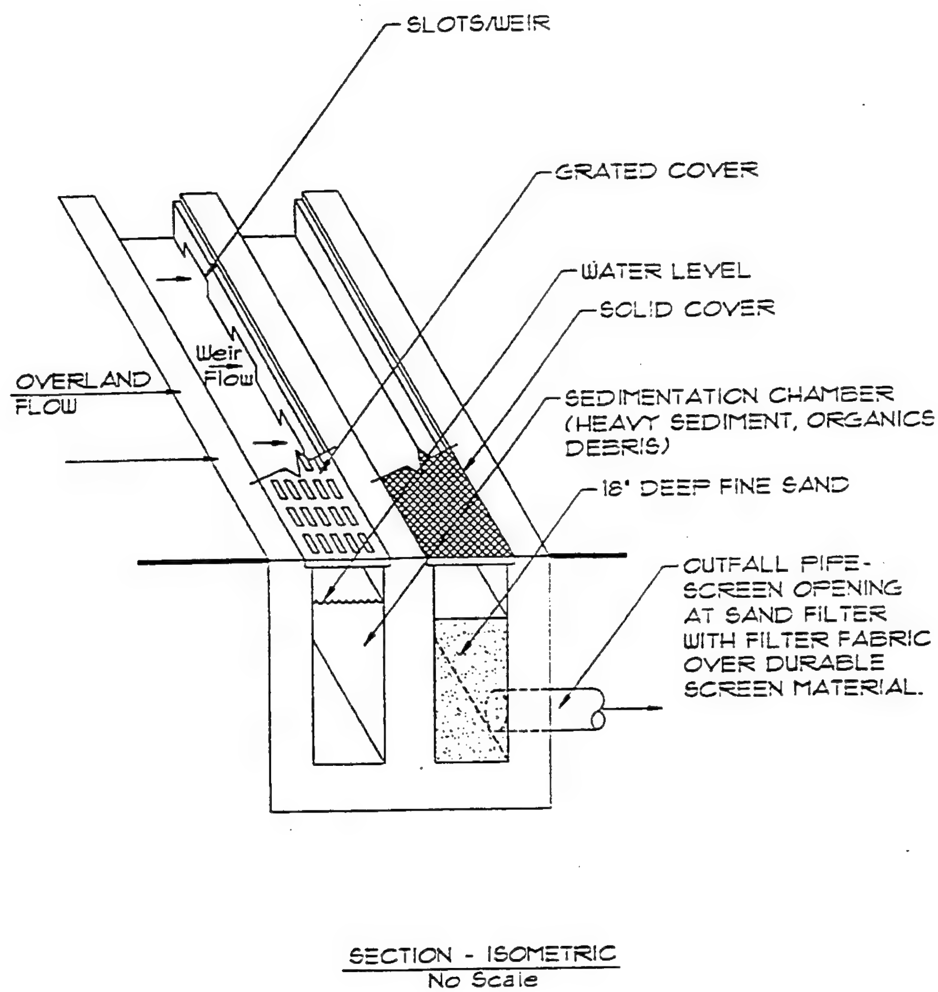
EXTENDED DETENTION PONDS

FIGURE 11



(Source: City of Austin (1988)
(Modified by WCC/Murase, 1994)

Figure 12
Sand Filter



Source: "Sand Filter Design for Water Quality Treatment"

Figure 13
Delaware Sand Filter

APPENDIX A

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APPENDIX B

HYDROLOGIC ANALYSIS

SECTION 22 PLANNING ASSISTANCE TO STATES
RUNNINS RIVER WATERSHED
STORMWATER MANAGEMENT STUDY
EAST PROVIDENCE, RHODE ISLAND

HYDROLOGIC ANALYSIS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS 02254-9149

FEBRUARY 1994

RUNNINS RIVER WATERSHED
STORMWATER MANAGEMENT STUDY
EAST PROVIDENCE, RHODE ISLAND

HYDROLOGIC ANALYSIS

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RUNNINS RIVER WATERSHED
STORMWATER MANAGEMENT STUDY
EAST PROVIDENCE, RHODE ISLAND

HYDROLOGIC ANALYSIS

1. PURPOSE

This stormwater management study presents results of a hydrologic analysis of the Runnins River in Rehoboth and Seekonk, Massachusetts, and East Providence, Rhode Island. The study was performed under authority contained in the Section 22, Planning Assistance to States Program. Water quality degradation, resulting from stormwater inflow to the river has adversely affected the Barrington River, which is the receiving water of the Runnins River. The Barrington River flows into Hundred Acre Cove, once a fertile shellfishing area, which had to be closed in recent years due to poor water quality.

Although this analysis considers the entire drainage area of the Runnins River, the focus of effort is on East Providence, Rhode Island, the local sponsor. This report presents information on climatology, streamflow characteristics, and potential impacts of future development.

2. WATERSHED DESCRIPTION

The Runnins River has a total drainage area of about 9.87 square miles at the Mobil Dam, see plate 1. The headwaters of the Runnins River watershed are in Rehoboth, Massachusetts; however, the actual river begins in Seekonk, Massachusetts, where it flows generally southwesterly through the town.

After flowing about 5 miles, the river becomes the State border between Seekonk, Massachusetts, and East Providence, Rhode Island. Here the river turns southward and flows in a south to southeasterly direction to the Mobil Dam. Downstream of this dam, the Runnins becomes the Barrington River, merging with the Palmer River to become the Warren River, which eventually discharges into Narragansett Bay.

The upper watershed of the Runnins River is relatively undeveloped with only small residential areas, numerous wetlands, and forested areas. A USGS staff gage is located at Pleasant Street in the town of Seekonk, Massachusetts (drainage area of 4.24 square miles). Annual peak stages and flows were measured by the USGS at Pleasant Street from 1967 to 1983. Since 1984, miscellaneous readings have been taken

on a monthly basis as part of a local river monitoring program performed by the Pokanoket Watershed Alliance; however, peak annual flows are no longer recorded. Upstream of this gage, average slope of the river is about 11 feet per mile for its 4.2 mile length. About one-quarter of the watershed area provides runoff storage during rainfall events, either in wetlands or lakes and ponds.

Downstream of the gage to the Mobil Dam, the watershed changes character. East Providence, on the western border, is a mature, urbanized area, which Seekonk, on the eastern side, is rapidly developing, with increasing impervious areas and runoff rates. Although there is substantial storage provided just downstream of Pleasant Street by a large wetland area, there is little other storage provided through this reach. The average slope of the river through this reach changes to about 13 feet per mile for its 3-mile length.

For this study, the downstream limit of the Runnins River is assumed to be the Mobil Dam, built in the 1920s by Mobil Corporation to divert water to a pump house for industrial use at their Mobil facility. The dam consists of a small earthen berm, with a crest elevation estimated to be between 8 and 9 feet NGVD. The overflow section is a concrete wall about 85 feet long and 2 feet wide. Spillway crest is estimated at 4.5 feet NGVD. Dam and spillway crest elevations were approximated by field observations of the distance between crest and predicted tide heights for the area; therefore, these elevations are only a rough approximation.

The dam itself is in relatively good condition. The remains of some gate structures and sluiceways exist; however, it appears that any low level outlets were completely sealed. It seems that during normal tide ranges, the dam is the upstream limit of tidal influence; however, during storm tides above 4.5 feet NGVD (more frequent than a 1-year frequency tide), tidal influence can be expected as far upstream as Highland Avenue during a 100-year event.

Downstream of the Mobil Dam, the Runnins River becomes the Barrington, which flows into Hundred Acre Cove. Further downstream, the Barrington River merges with the Palmer to form the Warren River, which discharges into Narragansett Bay. The slope of the river in this reach is very flat, and flow depends on the tides (see the Water Quality Appendix).

3. CLIMATOLOGY

a. General. The Narragansett Bay area has a temperate and changeable climate characterized by four distinct

seasons. Due to the moderating influence of Narragansett Bay and the Atlantic Ocean, and particularly changing movements of high and low pressure systems approaching from the west and southwest, extremes of either hot or cold weather are rarely of long duration. In winter, coastal storms frequently bring rainfall to the shore areas. Fog from the ocean is often advected over land by onshore winds, occurring about 2 or 3 days per month in the East Providence area. High winds and heavy rainfall occur with unpredictable frequency, while hurricanes develop most frequently during August, September, and October.

b. Temperature. Since 1905, temperature records have been maintained at Providence, which abuts East Providence to the west. The mean annual temperature is approximately 50 degrees Fahrenheit, with 70 degree temperatures being common between May and September. July is the warmest month, averaging about 73 degrees. Freezing temperatures are common from late November through March, with January the coldest month averaging about 29 degrees. Table 1 is a summary of the mean monthly and maximum and minimum temperatures recorded at T.F. Green Airport, Providence, weather station. Temperatures are based on the 89-year period of record from 1905 to 1993.

TABLE 1

MONTHLY TEMPERATURE IN DEGREES FAHRENHEIT
PROVIDENCE, RHODE ISLAND
(Elevation 51 Feet NGVD, 89 Years of Record)

Month	Mean	Maximum	Minimum
January	29.0	66	-13
February	29.6	72	-7
March	37.8	80	1
April	47.7	98	14
May	58.1	94	29
June	67.0	97	41
July	72.7	102	48
August	71.1	104	40
September	63.8	100	33
October	53.8	86	20
November	43.5	78	6
December	32.7	70	-10
Annual	**50.6**	**104**	**-13**

c. Precipitation. Precipitation has been recorded since 1905 at Providence. Average annual precipitation at Providence is about 42.1 inches, distributed quite uniformly throughout the year, and averaging about 3.5 inches per month. Average and extreme monthly precipitation values are shown in table 2.

TABLE 2

MONTHLY PRECIPITATION IN INCHES
PROVIDENCE, RHODE ISLAND
(Elevation 51 Feet NGVD, 89 Years of Record)

Month	Mean	Maximum	Minimum
January	3.74	11.66	0.50
February	3.27	7.20	0.39
March	3.83	8.84	0.56
April	3.74	12.74	1.48
May	3.28	8.38	0.71
June	3.04	11.08	0.39
July	3.18	8.08	1.00
August	3.72	11.12	0.71
September	2.33	7.92	0.77
October	3.19	11.89	1.53
November	3.87	11.01	0.81
December	3.87	10.75	0.58
Annual	**42.08**	**67.52**	**25.44**

d. Snowfall. Snowfall in the Providence area averages about 35 inches per year, occurring primarily between late November and early April. Mean monthly snowfall recorded at the Providence National Weather Service station since 1954 is presented in table 3.

TABLE 3

MEAN MONTHLY SNOWFALL IN INCHES
PROVIDENCE, RHODE ISLAND
(Elevation 51 Feet NGVD, 40 Years of Record)

Month	Mean
January	9.5
February	9.5
March	7.4
April	0.8
May	Trace
June	0.0
July	0.0
August	0.0
September	0.0
October	0.1
November	1.0
December	6.9
Annual	**35.4**

e. Rainfall Frequencies. Short duration, intense rainfall often accompanies fast moving frontal systems, thunderstorms, and coastal storms. Peak storm rainfall frequency-duration data, as reported in U.S. Weather Bureau Technical Paper 40 (reference h), are summarized in table 4.

TABLE 4

RAINFALL FREQUENCY DURATION
USWB TECHNICAL PAPER 40
EAST PROVIDENCE, RHODE ISLAND
(Inches)

Annual Frequency		Duration in Hours				
Percent	Year	1	2	6	12	24
50	2	1.2	1.6	2.3	2.7	3.4
10	10	2.0	2.4	3.4	4.1	4.9
2	50	2.5	3.5	4.4	5.3	6.3
1	100	3.8	3.9	4.9	6.0	7.0

4. HYDROLOGIC ANALYSIS

a. General. The Runnins River watershed is mostly ungaged. The USGS installed a staff gage at Pleasant Street (drainage area 4.24 square miles) in 1967. From 1967 to 1983, peak annual flows were measured at this location. This data is useful for developing annual discharge frequency relationships. Since 1984, the gage has been randomly read; however, these miscellaneous readings cannot be directly analyzed, and must be correlated to similar continuously gaged index stations.

The emphasis of this study is on water quality and stormwater management for the Runnins River; therefore, most of the hydrologic analysis focuses on more frequent flood events, low flows, and flow durations.

b. Streamflow. As discussed above, limited flow data has been collected for the Runnins River. Available peak flow records were analyzed for this study and some of the miscellaneous readings were included in the analysis of low flows and flow durations. However, analyses of nearby, hydrologically similar gaged watersheds were performed to characterize the flow regime of the Runnins River. In addition, the U.S. Geological Survey has published several reports (references d through g) with regression equations, describing different flow characteristics based on physical watershed features. These regression equations were used in conjunction with results of the regional gage analyses to develop estimated flow characteristics for the Runnins River.

(1) Mean Flows. Mean monthly flows were analyzed at several gages for this study. Several gages in the same general area as the Runnins River, see plate 2, were chosen for analysis of mean monthly and annual flows. Mean annual flows for these four gaged locations are listed in table 5, and mean monthly flows are graphed on plate 3.

TABLE 5

MEAN ANNUAL FLOWS
AT SELECTED USGS GAGE LOCATIONS

Location	Drainage Area (sq. mi.)	Mean Annual Flow (cfs)
Beaver River near Usquepaug	8.9	21.8
Moshassuck River at Providence	23.1	40.6
Nipmuc River near Harrisville	16.0	30.7
Woonasquatucket River at Centerdale	38.3	73.1

Using the results of this analysis with methods described in USGS report "Estimating Surface-Water Runoff to Narragansett Bay, Rhode Island and Massachusetts" (reference d), estimates of mean monthly runoff were developed for the Runnins River at Fall River Avenue and School Street. These flows are plotted on plate 4. Approximate mean annual flows are 21.5 cfs at School Street (DA = 9.39 square miles) and 13.5 cfs at Fall River Avenue (DA = 5.92 square miles) as published by the USGS.

(2) Flow Durations. Flow duration analyses were performed at the same gages as analysis of mean monthly flows. The Beaver, Moshassuck, Nipmuc, and Woonasquatucket Rivers were chosen because of minimal regulation and diversion during the period of record at the gages. Flow duration curves for these gages are shown on plate 5.

Based on this gage analysis, a flow duration curve was estimated for the Runnins River. Because both the Moshassuck and Woonasquatucket Rivers experience some occasional regulation during low flows, the flow duration curve for the Nipmuc River was used as a basis for flows on the Runnins River. The approximate flow duration curve for the Runnins River is shown on plate 6.

(3) Low Flows. Low flow frequency curves were developed for the Moshassuck, Nipmuc, and Woonasquatucket Rivers using a log Pearson Type III analysis. Curves were calculated for 1, 7, 14, 30, 90, and 183-day durations at each site. These curves are shown on plate 7.

The low flow frequency curves for the Moshassuck and Woonasquatucket Rivers are generally close in value; however, curves for the Nipmuc River are well below those at the other two gages. This may be due partly to occasional regulation of upstream reservoirs within the Moshassuck and Woonasquatucket watersheds, which tends to increase low flow discharges as water is released from storage. The Nipmuc River is completely unregulated, relying on releases from wetlands and groundwater during periods of low flow and, therefore, is considered a more reasonable estimate for Runnins River low flows.

The USGS publication "Low-Flow Characteristics of Selected Streams in Rhode Island" (reference e) presents regression equations for estimating the 7-day, 10-year low flow (${}_7Q_{10}$) in areas that do not drain urbanized watersheds. Since the East Providence and Seekonk portions of the Runnins watershed are urbanized in many areas, the USGS equation, relating area underlain by till and area underlain by

coarse-grained stratified drift, should not be used to estimate the $_7Q_{10}$ for the Runnins River. Using this equation, the $_7Q_{10}$ would be 4.6 cfs, much higher than partial gage analyses performed by the USGS in "Gazetteer of Hydrologic Characteristics. . ." (reference g). This report estimates the $_7Q_{10}$ and $_7Q_2$ for the Runnins River at Pleasant Street as less than 0.1 and 0.2 cfs, respectively. Due to the wide range in values developed by these sources, results of the regional gage analysis were used to develop the low flow frequency estimate for the Runnins River, shown on plate 8. This curve is based on computed values for the Nipmuc River and, therefore, is only an estimate of 7-day low flows on the Runnins River.

(4) Discharge Frequencies. Annual peak flow records from 1967 to 1983, at the USGS gaging station at Pleasant Street, were analyzed to calculate discharge frequencies for the Runnins River. A log Pearson Type III distribution was applied to the peak annual flows for the period of record at the gage. This analysis yielded a mean log of 1.9971, standard deviation of 0.1081, and adopted skew of 0.5. Results of this analysis are listed in table 6 and shown graphically on plate 9.

TABLE 6

DISCHARGE FREQUENCY RELATIONSHIP
RUNNINS RIVER AT PLEASANT STREET
(Drainage Area = 4.24 sq. mi.)

Event (year)	Peak Flow (cfs)
2	97
10	140
50	190
100	220

c. Watershed Model

(1) General. A rainfall-runoff model of the Runnins River was developed using the Corps of Engineers computer program HEC-1 (reference b). A combination of Modified Puls storage routing and Muskingum-Cunge dynamic routing methods were employed to estimate runoff hydrographs from the watershed, resulting from different rainfall events. Modified Puls routing was used primarily in the upstream reaches where significant storage capacity is provided by the extensive wetland system. Muskingum-Cunge routing was used in the downstream reaches, with little available storage. Both methods account for watershed slope, land cover, and losses

as well as channel characteristics. The model was generally calibrated to within 10 percent of discharges developed from the analysis of the USGS gage at Pleasant Street, as well as published discharges from the 1979 Flood Insurance Study for Seekonk, Massachusetts (reference i).

To aid in analysis of water quality parameters, sub-watersheds were delineated and modelled at all water quality sampling stations used by the Pokanoket Watershed Alliance, shown on plate 10. This analysis includes estimated peak discharges for the 2, 10, 50, and 100-year rainfall events as reported in the U.S. Weather Bureau Technical Publication 40 (reference h) and listed previously in table 4.

(b) Existing Conditions. The HEC-1 rainfall-runoff model was developed for existing conditions in the watershed. Loss rates were estimated using the SCS curve number method, based on existing land use and cover within the drainage area.

Rainfall for the 2, 10, 50, and 100-year, 24-hour events was applied to the watershed. Runoff from each subbasin was routed downstream to the Mobil Dam, using appropriate routing techniques; discharges were calibrated to the Flood Insurance Study and gage data. The results of this analysis are presented in table 7, which lists index stations and peak runoff rates for each different frequency event analyzed. Plate 11 shows development of the 100-year flood hydrograph at Pleasant Street and the Mobil Dam.

TABLE 7

COMPUTED PEAK FLOWS
AT WATER QUALITY SAMPLING STATIONS

Location	Total Drainage Area (sq. mi.)	Computed Peak Flows in CFS 2-Yr	10-Yr	50-Yr	100-Yr
Walnut Street	1.15	5	10	20	40
Prospect Street	1.83	10	15	35	65
Woodward Street	1.90	15	20	40	75
Greenwood Street	2.72	50	70	100	130
Arcade Avenue	3.55	65	90	150	180
Taunton Avenue	4.22	85	115	180	220
Pleasant Street	4.24	90	125	185	225
Fall River Avenue	5.85	110	145	255	330
County Street	7.07	115	155	280	365
Highland Avenue	7.36	120	160	495	380
Mink Street	9.04	185	250	405	505
School Street	9.39	190	260	435	550
Mobil Dam	9.87	205	280	465	595

Peak flows in the Runnins River are significantly attenuated by storage in wetlands and ponds of the upper watershed (generally above Arcade Avenue). Runoff fills this storage and is gradually released after peak flows have passed. This results in a hydrograph with a lower peak discharge and longer recession limb, than would be expected for a similar size drainage basin without any storage.

(c) Future Conditions. The future condition scenarios described in this section are not forecasts of expected development. These conditions are meant to show an approximation of what might be expected, as a result of different types of development occurring in different portions of the watershed. The effects of this development were modelled primarily as a decrease in loss rates in the affected subbasins.

Two different future development conditions were analyzed. The first scenario assumes that the watershed upstream of Arcade Avenue (drainage area = 3.55 square miles) experiences a 10 percent increase in impervious surface area. The second assumes that the Mink Street subbasin (drainage area = 1.68 square miles), containing the rapidly developing Route 6 area, experiences a 10 percent increase in impervious area over existing conditions. Table 8 illustrates the impact of each scenario on peak discharges at the Mobil Dam; plate 12 shows the computed hydrographs at Pleasant Street and Mobil Dam for each future condition.

TABLE 8

EFFECTS OF FUTURE DEVELOPMENT ON PEAK DISCHARGES ON THE RUNNINS RIVER AT THE MOBIL DAM

Event (year)	Existing Conditions Discharge (cfs)	Development Upstream of Arcade Avenue Discharge (cfs)	Development Along Route 6 Discharge (cfs)
2	205	210	215
10	280	285	295
50	465	470	495
100	595	610	680

The time to peak for the first scenario is the same as the time to peak for existing conditions, since most peak runoff is from the more urbanized downstream subbasins. Development of the upstream subbasins results in a small increase in peak discharge; however, this assumes that the upstream storage areas remain unchanged (i.e., no loss in storage capacity). If this upstream storage capacity is lost, peak discharges would be expected to increase. In addition, discharges from the upper watershed would peak sooner, adding further to experienced peak flows downstream.

Development in the downstream Route 6 area will tend to yield an earlier peak and larger increase in experienced flood discharges because peak discharges at the Mobil Dam are mostly from the watershed downstream of Fall River Avenue, where there is little storage and hydrographs peak quickly.

Impacts from higher discharges and runoff volume; as a result of increased development in the upstream portions of the watershed, will affect a larger area because discharges are higher throughout the entire river system. Impacts from development in downstream areas in the watershed will be less widespread because increased flow travels less distance through the system.

d. East Providence Watershed Area. East Providence contributes about 2.30 square miles to the 9.87 square mile Runnins River watershed (about 23 percent of the drainage area). Three small tributaries to the Runnins River originate in East Providence (see plate 13).

The northernmost tributary starts near Waterman Avenue and drains the area around East Providence High School. This tributary flows through some wetland areas and enters the Runnins River in Seekonk, Massachusetts. Total drainage area of the East Providence High School tributary is 1.08 square miles.

A second tributary drains the Armington Corner section of East Providence. Locals call this tributary Orange Juice Creek, which has a total drainage area of about 0.59 square mile.

The southern tributary begins at Gate of Heaven Cemetery, flowing adjacent to a gravel pit before discharging into the Runnins River. Cemetery Tributary drains approximately 0.18 square mile.

e. Hundred Acre Cove. Hundred Acre Cove is a tidally influenced cove on the Barrington River about 2 miles

downstream of the Mobil Dam (see plate 1). Total drainage area of Hundred-Acre Cove is about 13.75 square miles, which the Runnins River drains about 9.87 square miles, over 70 percent of the total contributing watershed.

Most of the remaining 3.88-square mile drainage area is just south of Route 6 in Seekonk. This portion is relatively flat, with numerous wetland areas throughout the watershed.

Since the cove is not in the main flow path of the Barrington River, flushing of the area depends mostly on tidal action (see the Water Quality Appendix for additional information). The mean tide range at Warren, Rhode Island, is 4.6 feet, between -1.7 and 2.9 feet NGVD.

5. REFERENCES

a. U.S. Army Corps of Engineers, Draft Engineer Manual 1110-2-9021, Flood Runoff Analyses, 15 April 1993.

b. U.S. Army Corps of Engineers, Hydrologic Engineering Center, "HEC-1 Flood Hydrograph Package," User's Manual, September 1990.

c. U.S. Department of the Interior, Geological Survey, Office of Water Data Coordination, Interagency Advisory Committee on Water Data, "Guidelines for Determining Flood Flow Frequency," Bulletin 17B, 1982.

d. U.S. Department of the Interior, Geological Survey, Water-Resources Investigations Report 89-4164, "Estimating Surface Water Runoff to Narragansett Bay, Rhode Island and Massachusetts," 1990.

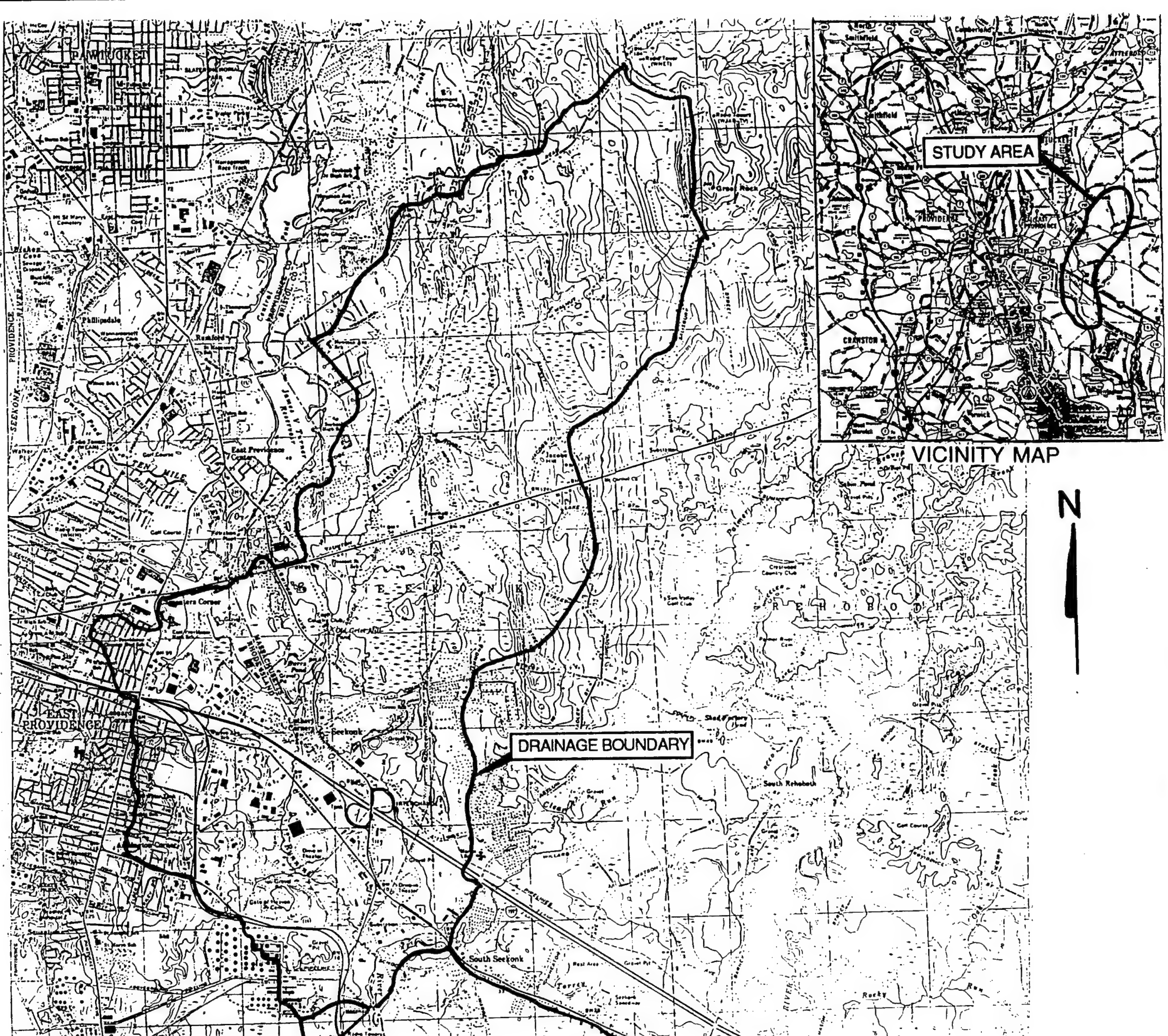
e. U.S. Department of the Interior, Geological Survey, Water-Resources Investigations Report 93-4046, "Low-Flow Characteristics of Selected Streams in Rhode Island," 1993.

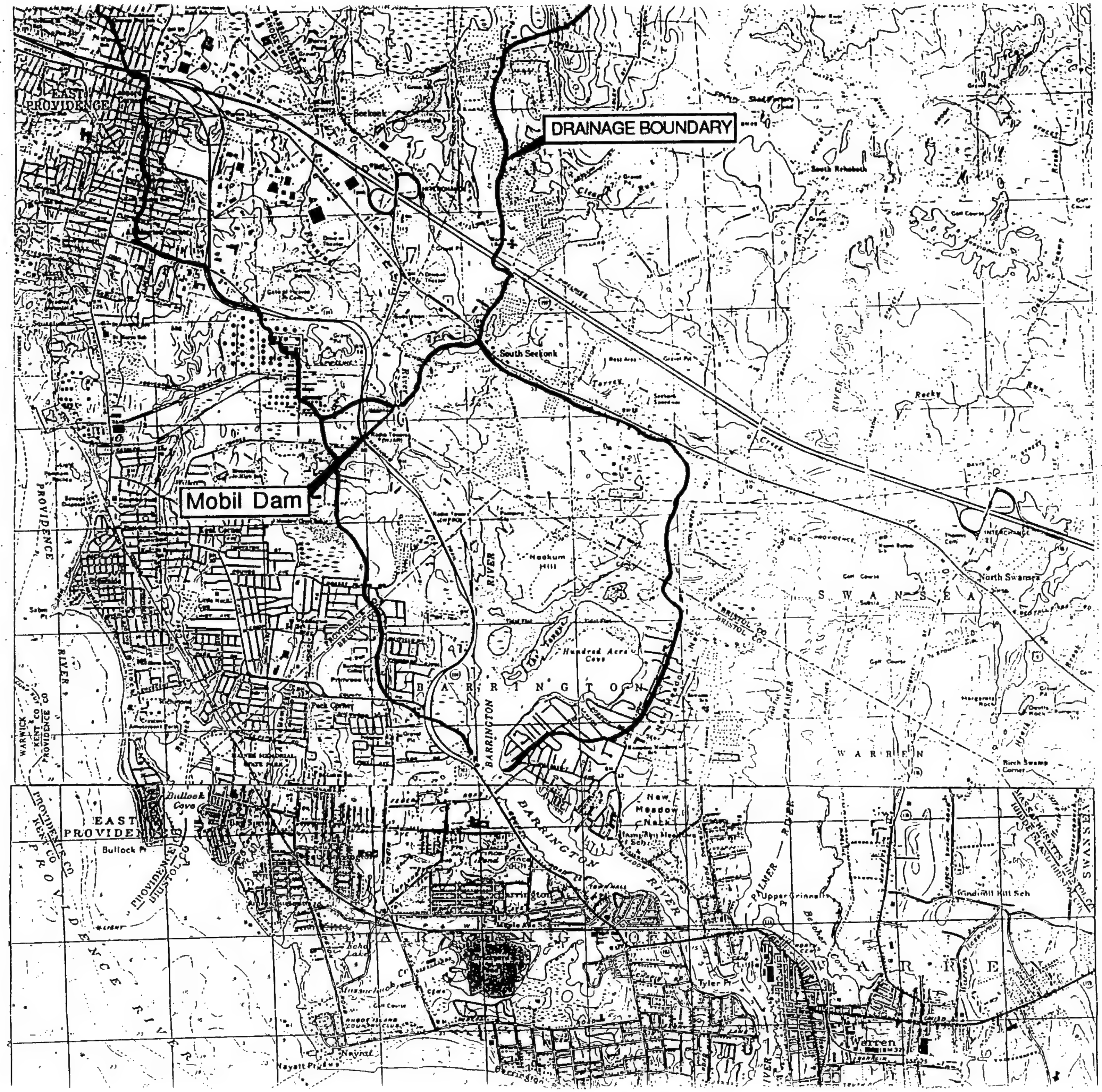
f. U.S. Department of the Interior, Geological Survey, Open-File Report 93-38, "Estimation of Low-Flow Duration Discharges in Massachusetts," 1993.

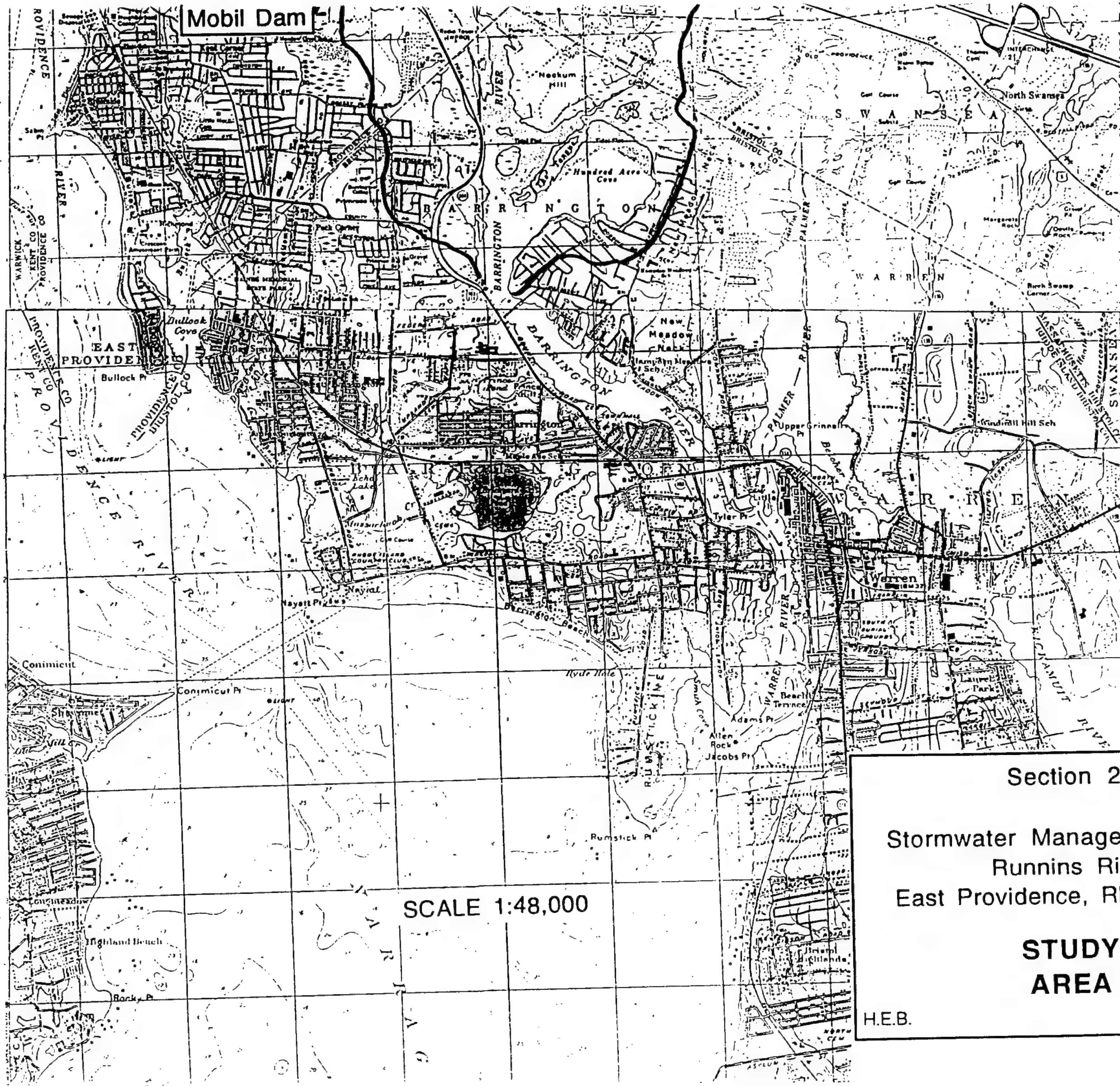
g. U.S. Department of the Interior, Geological Survey, Water-Resources Investigations Report 84-4283, "Gazetteer of Hydrologic Characteristics of Streams in Massachusetts -- Taunton and Ten Mile River Basins and Coastal River Basins of Mount Hope Bay, Narragansett Bay, and Rhode Island Sound," 1984.

h. U.S. Department of Commerce, Weather Bureau, Technical Paper No. 40, "Rainfall Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," 1961.

i. U.S. Department of Housing and Urban Development, "Flood Insurance Study for Seekonk, Massachusetts, Bristol County," March 1979.


STUDY AREA
VICINITY MAP
N
DRAINAGE BOUNDARY
PAWTUCKET
EAST PROVIDENCE
SEEKONK
REHOBOTH
South Seekonk
South Rehoboth
TEN MILE
PROVIDENCE RIVER
Phillipsdale
Rumford
East Providence Center
CRANSTON


DRAINAGE BOUNDARY
Mobil Dam
EAST PROVIDENCE
South Seekonk
South Rehoboth
SWANSEA
North Swansea
BARRINGTON
BARRINGTON RIVER
PALMER RIVER
PROVIDENCE RIVER
WARREN
Warren
Hundred Acre Cove
New Meadow Neck
Bullock Cove
Bullock Pt
Rocky Run
BRISTOL CO
PROVIDENCE CO
KENT CO
WARWICK



Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

STUDY AREA

H.E.B. Feb 199

PLATE 1

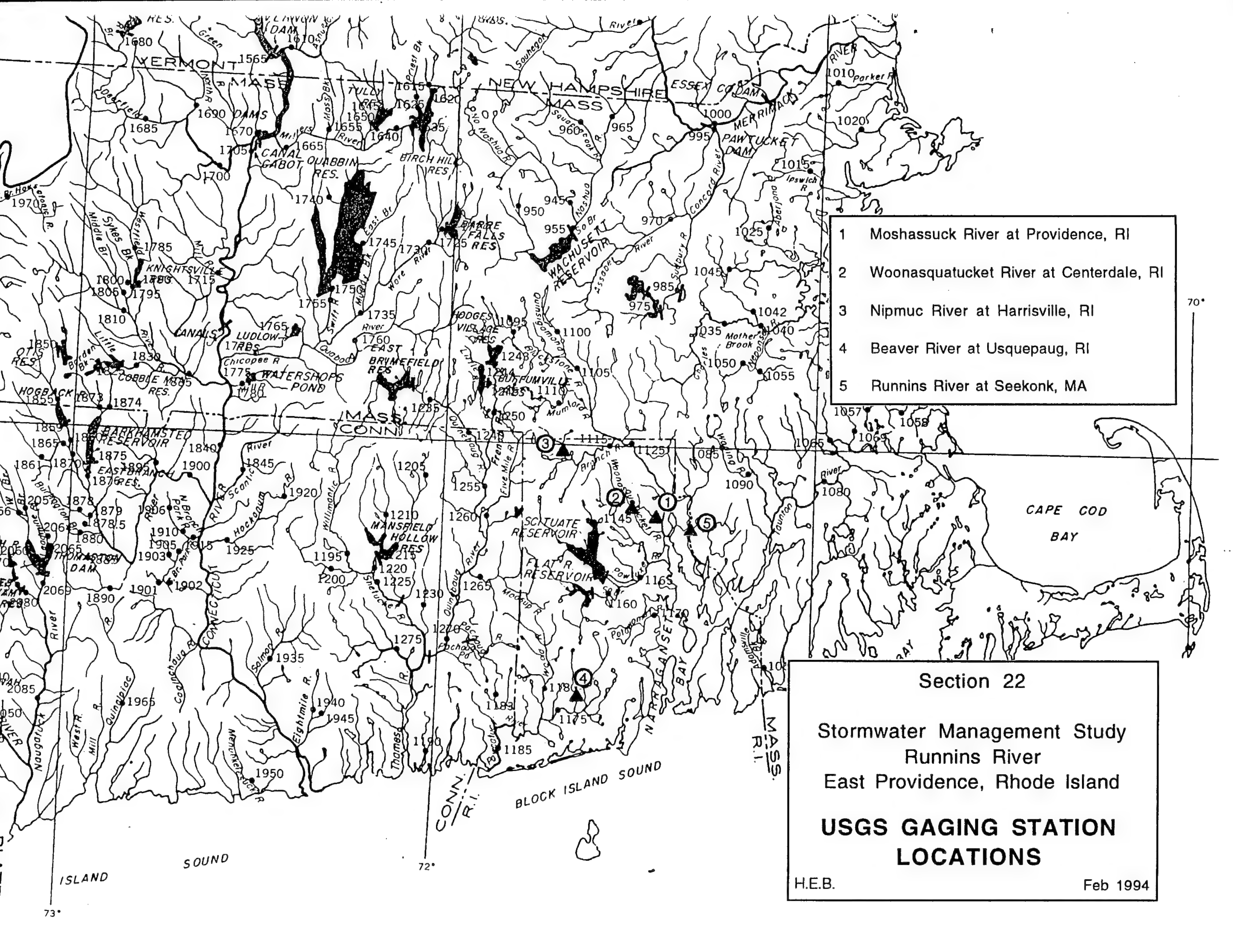
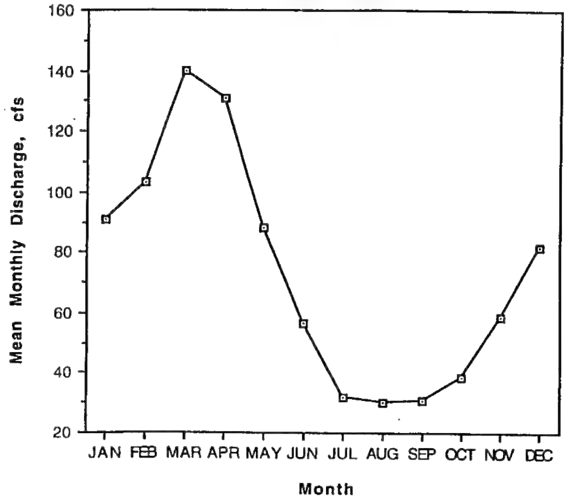
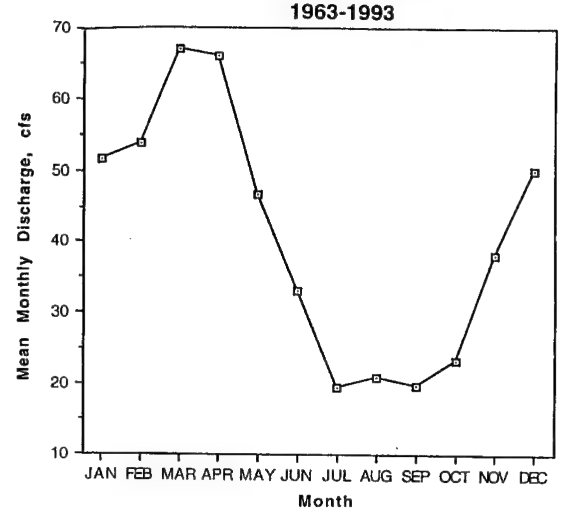

1 Moshassuck River at Providence, RI
2 Woonasquatucket River at Centerdale, RI
3 Nipmuc River at Harrisville, RI
4 Beaver River at Usquepaug, RI
5 Runnins River at Seekonk, MA
Section 22
Stormwater Management Study
Runnins River
East Providence, Rhode Island
USGS GAGING STATION LOCATIONS
H.E.B.
Feb 1994
CAPE COD BAY
BLOCK ISLAND SOUND
NARRAGANSETT BAY
MASS.
R.I.
CONN.
VERMONT
NEW HAMPSHIRE
SCITUATE RESERVOIR
WACHUSETT RESERVOIR
QUABBIN RES.
72°
73°
70°

PLATE 2

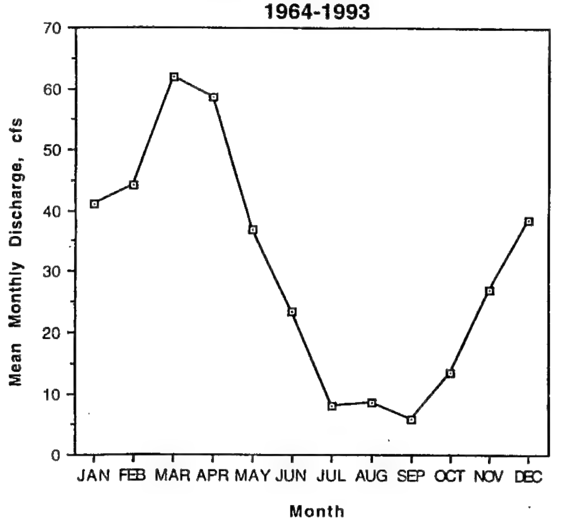
Woonasquatucket River at Centerdale, RI
D.A. = 38.3 sq. mi.
1941-1993



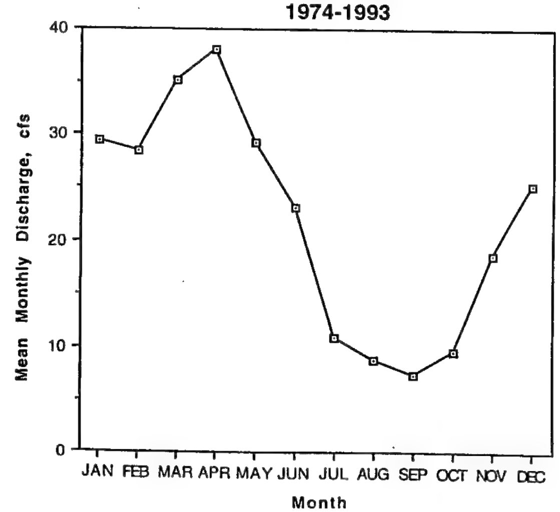
Moshassuck River at Providence, RI
D.A. = 23.1 sq. mi.
1963-1993



Nipmuc River near Harrisville, RI
D.A. = 16.0 sq. mi.
1964-1993



Beaver River near Usquepaug, RI
D.A. = 8.87 sq. mi.
1974-1993



Note differing scales

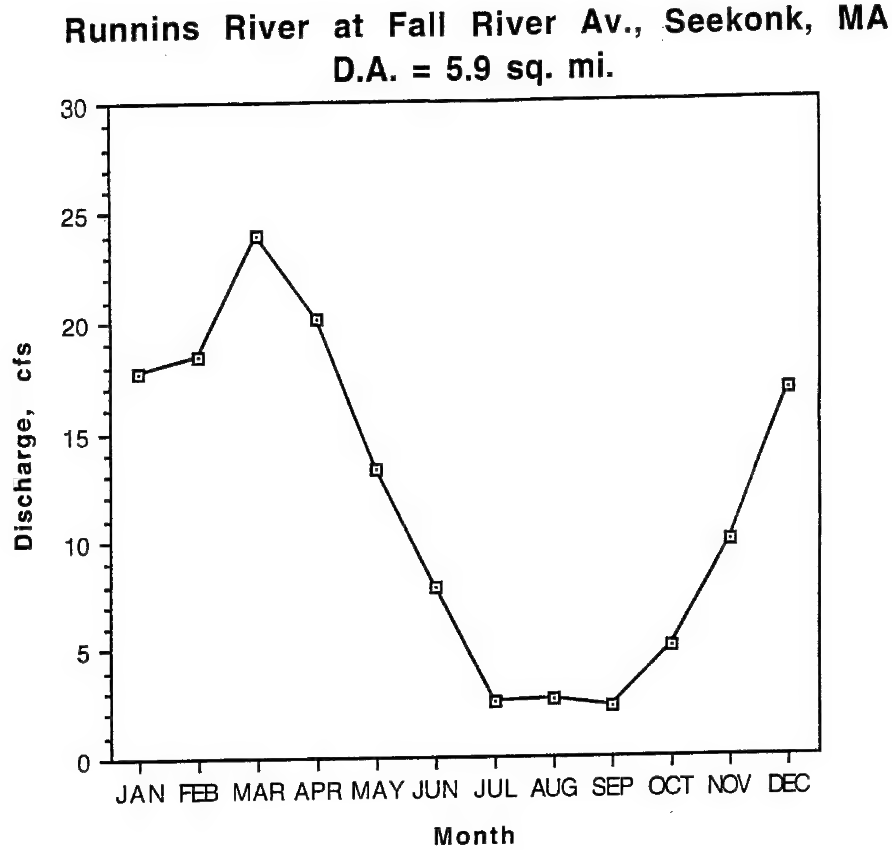
Section 22

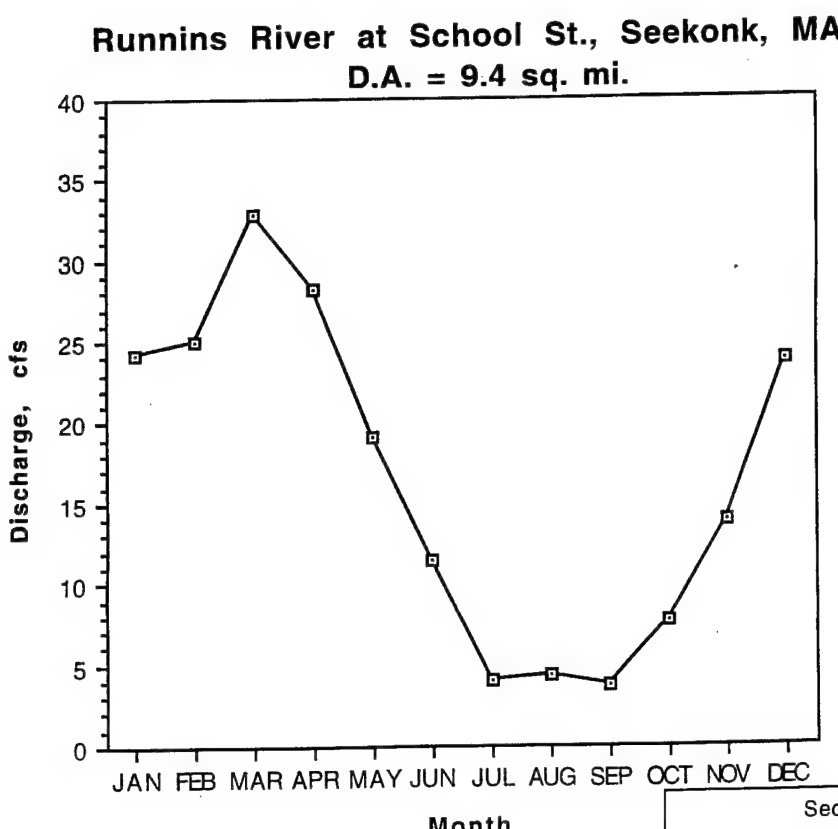
Stormwater Management Study
Runnins River
East Providence, Rhode Island

MEAN MONTHLY FLOW CURVES

H.E.B. Feb 1994

PLATE 3





Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

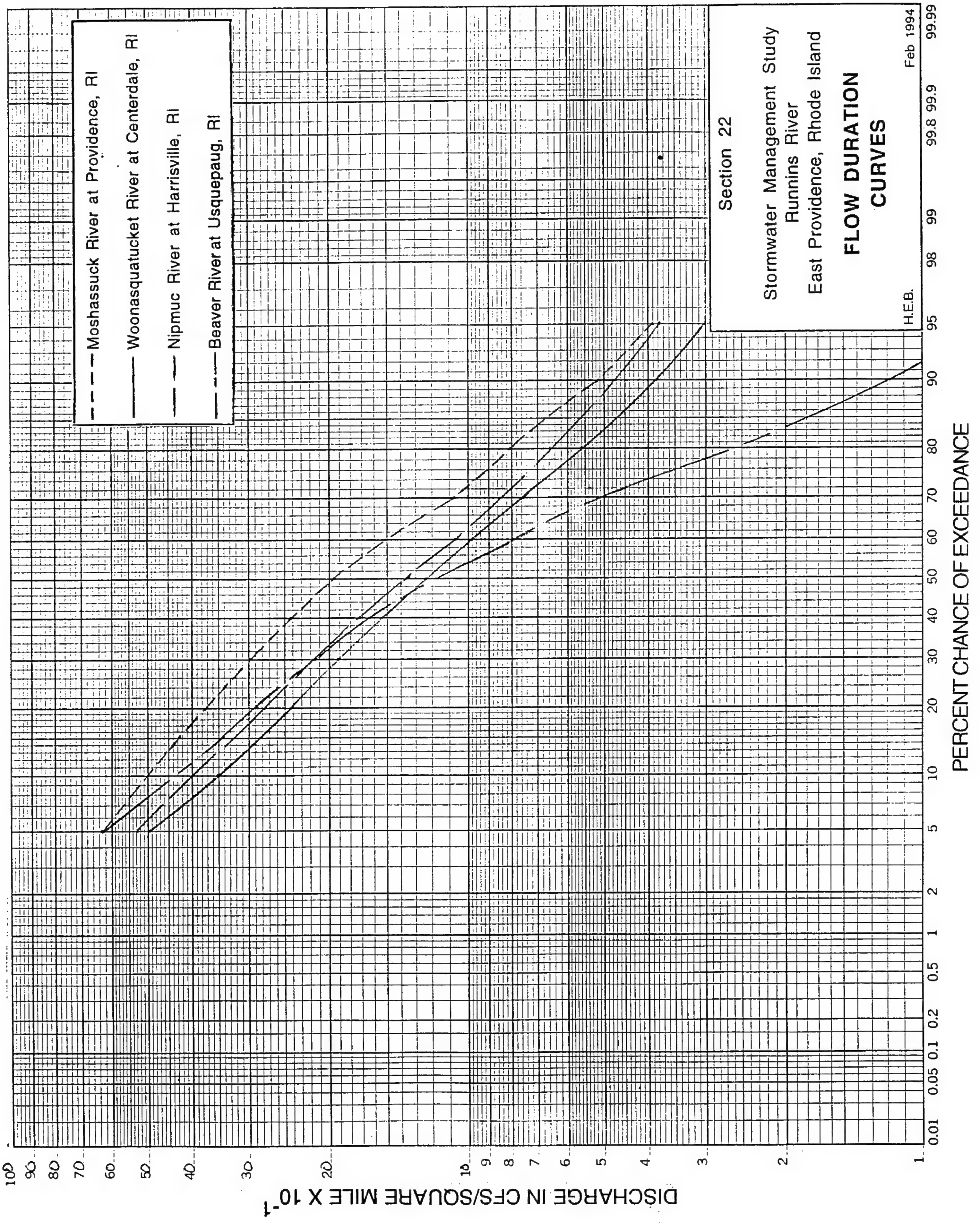
MEAN MONTHLY FLOW CURVES

H.E.B. Feb 1994

NOTE: Mean monthly runoff estimates based on regression equations developed in USGS report "Estimating Surface-Water Runoff to Narragansett Bay, Rhode Island and Massachusetts."

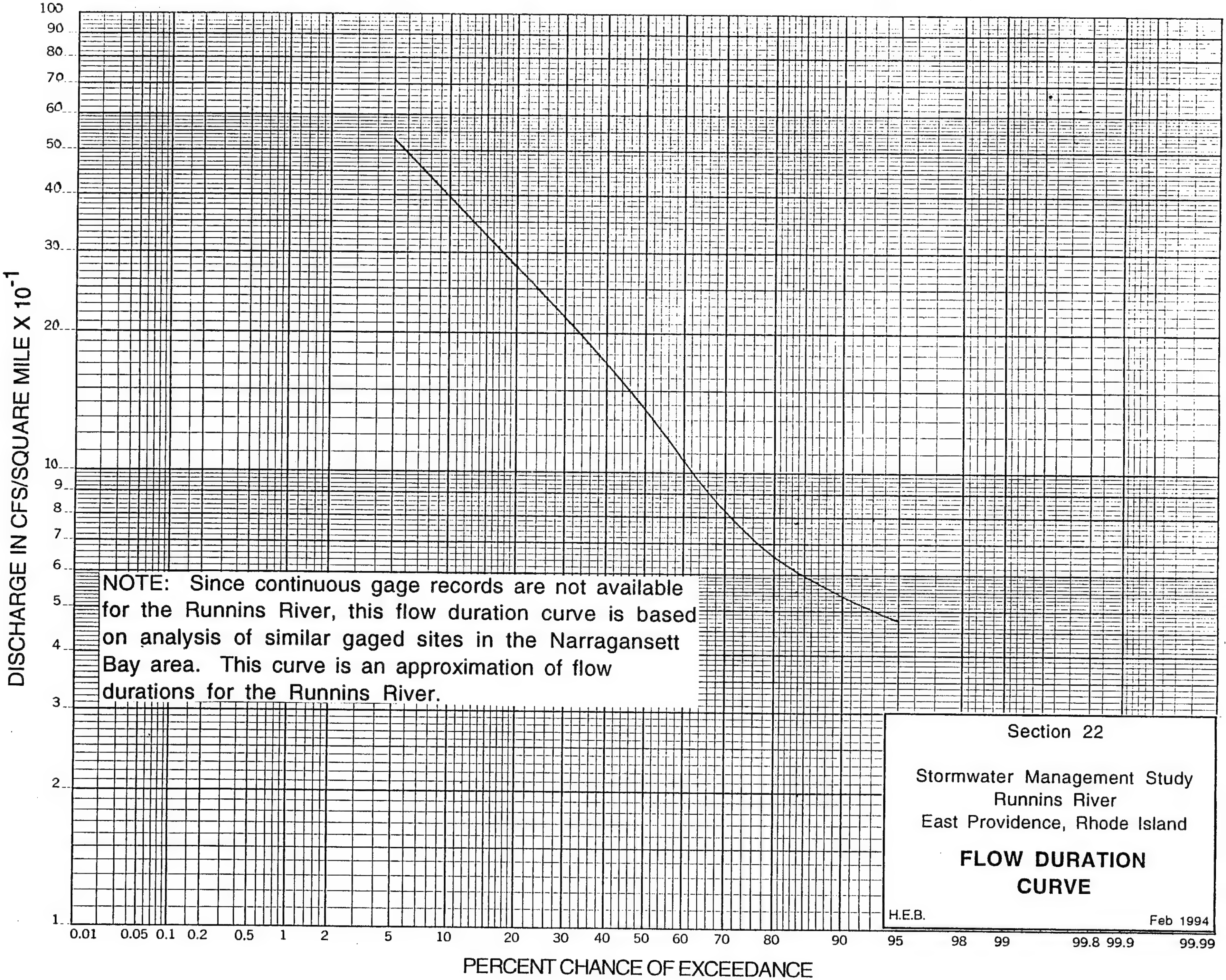
Note differing scales

PLATE 4

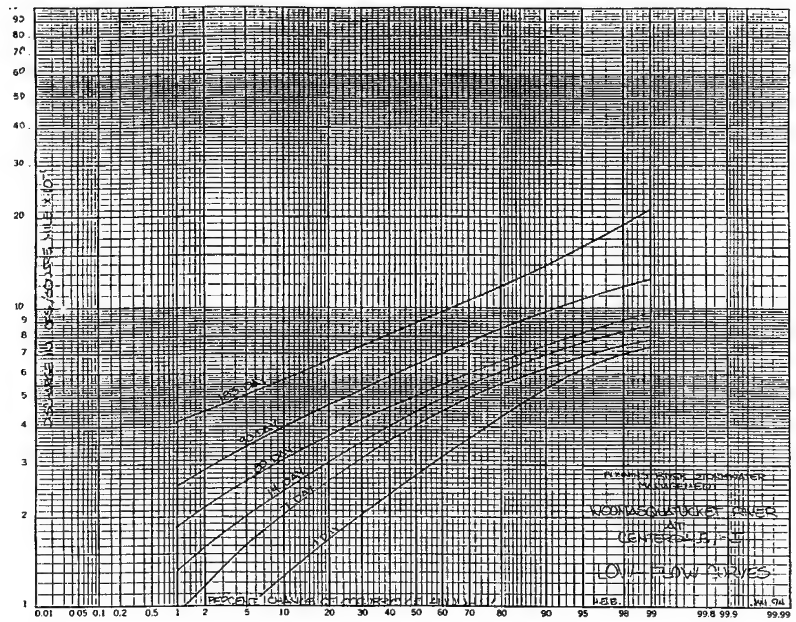


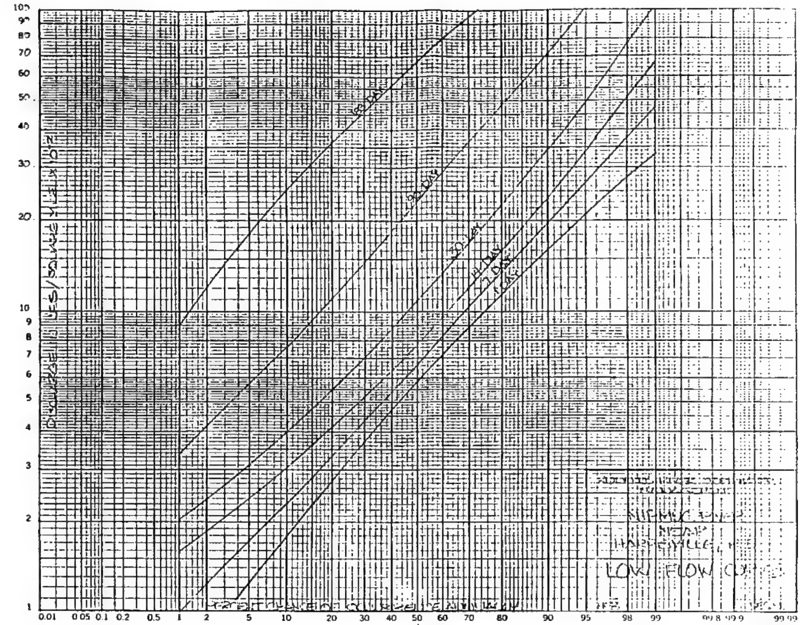
Moshassuck River at Providence, RI
Woonasquatucket River at Centerdale, RI
Nipmuc River at Harrisville, RI
Beaver River at Usquepaug, RI
Section 22
Stormwater Management Study
Runnins River
East Providence, Rhode Island
FLOW DURATION CURVES
H.E.B.
Feb 1994
PERCENT CHANCE OF EXCEEDANCE
DISCHARGE IN CFS/SQUARE MILE X 10-1
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
100 90 80 70 60 50 40 30 20 10 9 8 7 6 5 4 3 2 1

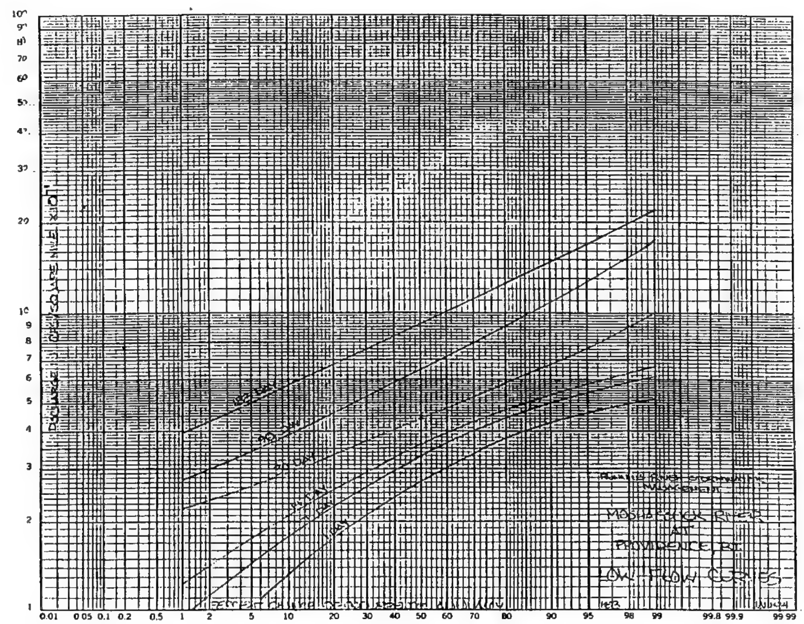
PLATE 5



100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
DISCHARGE IN CFS/SQUARE MILE X 10^-1
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
PERCENT CHANCE OF EXCEEDANCE
NOTE: Since continuous gage records are not available for the Runnins River, this flow duration curve is based on analysis of similar gaged sites in the Narragansett Bay area. This curve is an approximation of flow durations for the Runnins River.
Section 22
Stormwater Management Study
Runnins River
East Providence, Rhode Island
FLOW DURATION
CURVE
H.E.B.
Feb 1994







Section 22

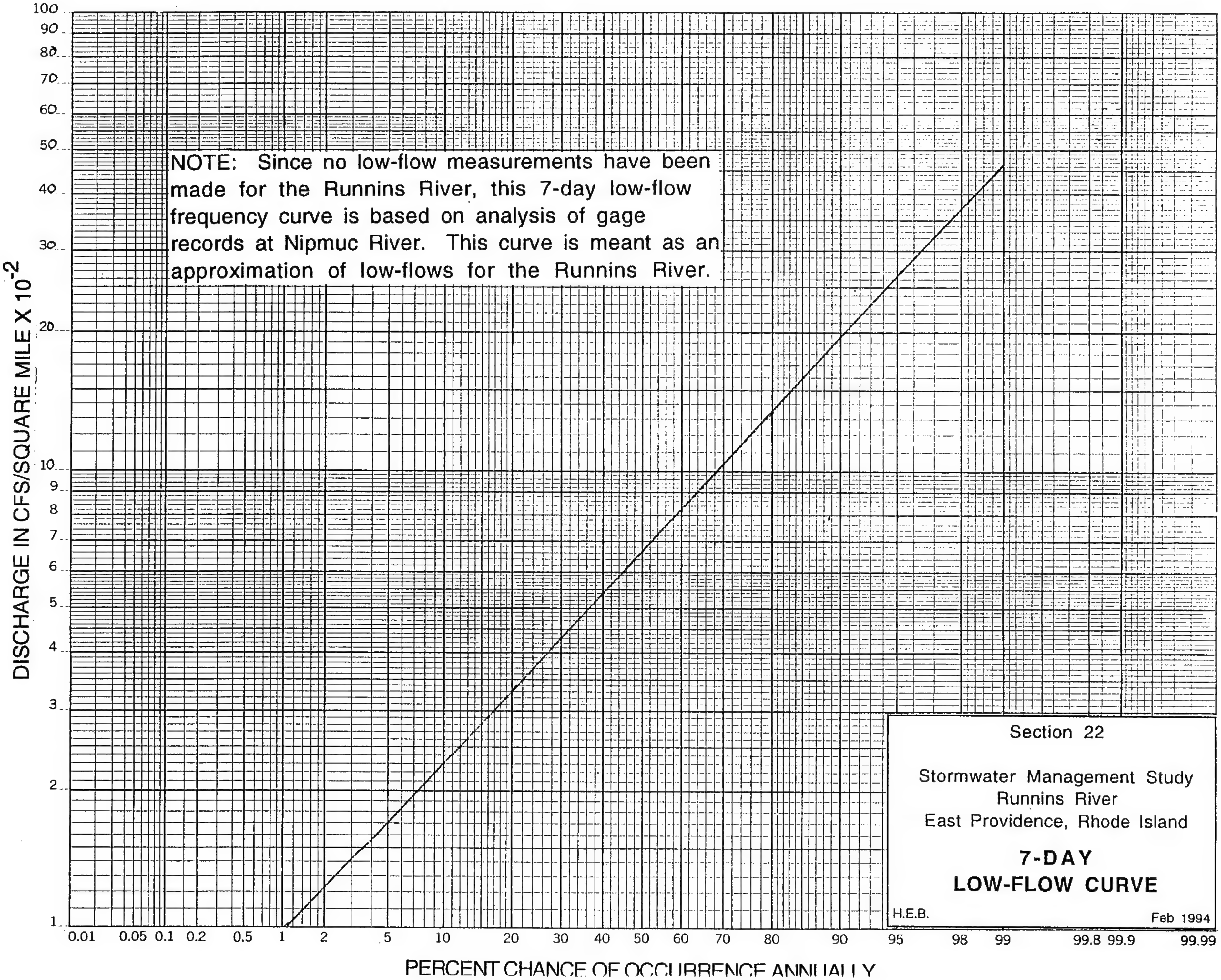
Stormwater Management Study
Runnins River
East Providence, Rhode Island

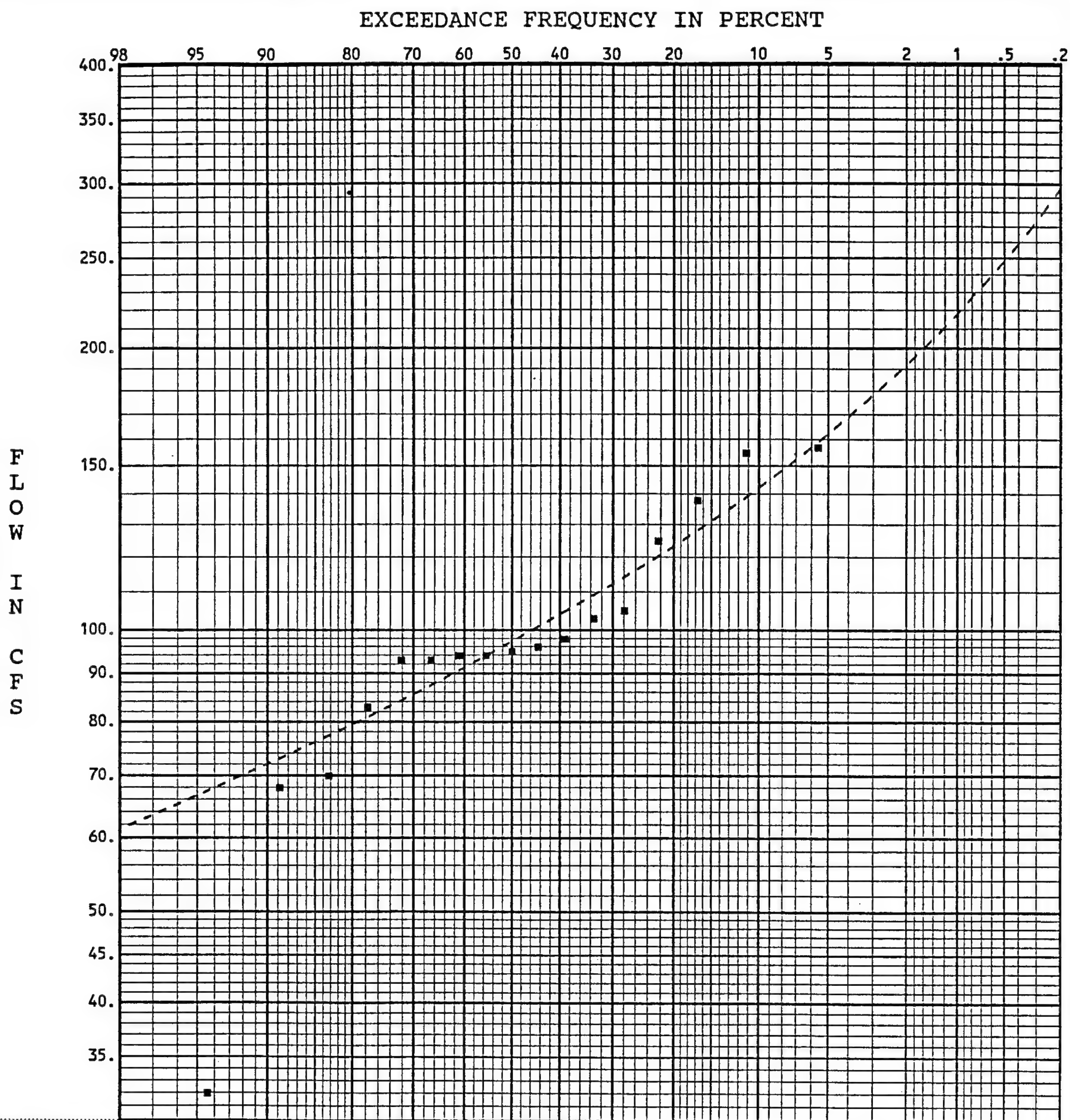
LOW-FLOW CURVES

H.E.B.

Feb 1994

PLATE 7


NOTE: Since no low-flow measurements have been made for the Runnins River, this 7-day low-flow frequency curve is based on analysis of gage records at Nipmuc River. This curve is meant as an approximation of low-flows for the Runnins River.
Section 22
Stormwater Management Study
Runnins River
East Providence, Rhode Island
7-DAY
LOW-FLOW CURVE
H.E.B.
Feb 1994
DISCHARGE IN CFS/SQUARE MILE X 10-2
PERCENT CHANCE OF OCCURRENCE ANNUALLY
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99



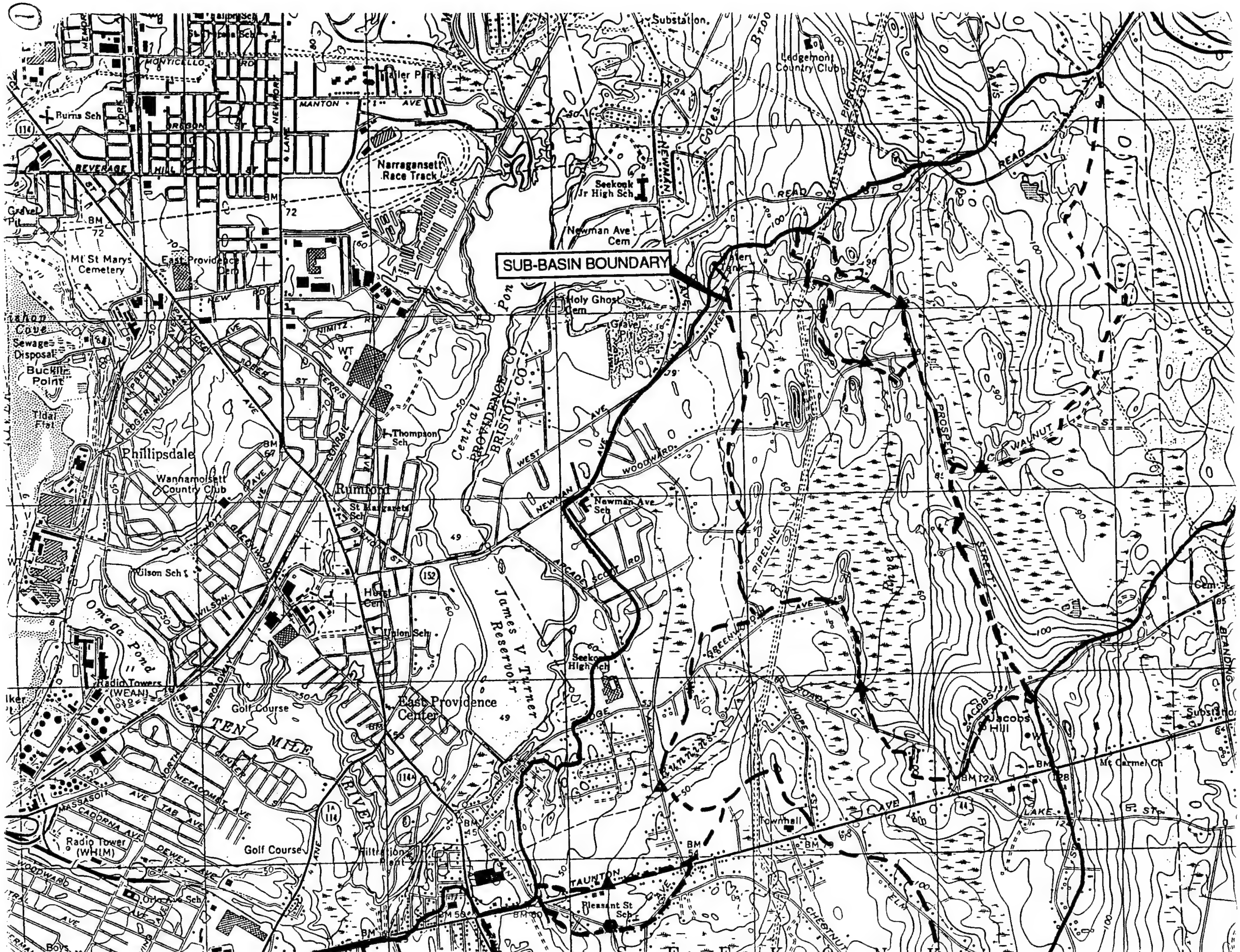
--- Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions

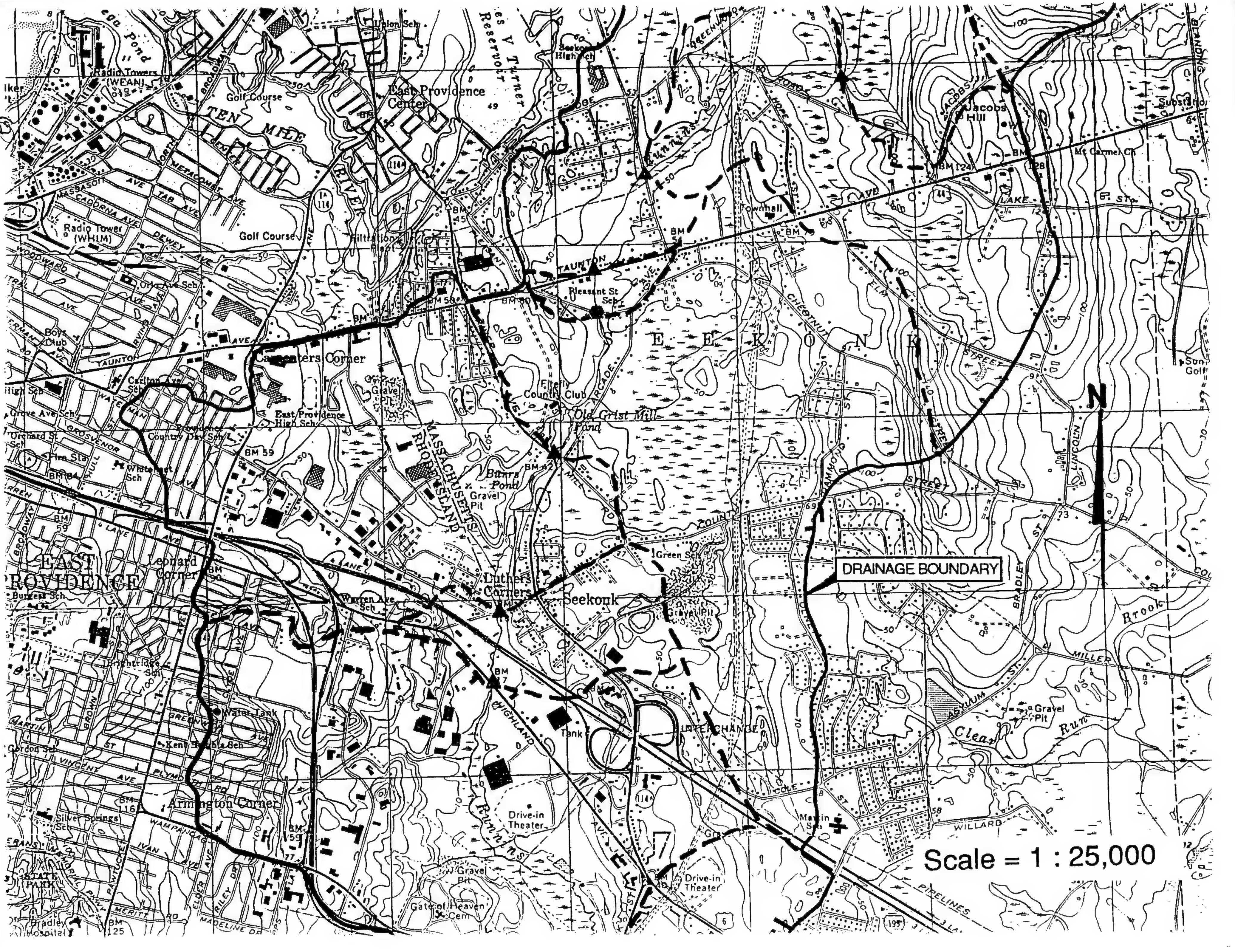
FREQUENCY STATISTICS
LOG TRANSFORM OF FLOW, CFS

		NUMBER OF EVENTS	
MEAN	1.9971	HISTORIC EVENTS	0
STANDARD DEV	.1081	HIGH OUTLIERS	0
SKEW	.3809	LOW OUTLIERS	1
REGIONAL SKEW	.7000	ZERO OR MISSING	0
ADOPTED SKEW	.5000	SYSTEMATIC EVENTS	17

FLOOD FLOW FREQUENCY
Runnins River
at Pleasant St, Seekonk, MA
BASIN AREA = 4.24 SQ MI
WATER YEARS IN RECORD
1967-1983

1


SUB-BASIN BOUNDARY
Ledgemont Country Club
Narragansett Race Track
Seekonk Jr High Sch
Newman Ave Cem
Holy Ghost Cem
Mt St Marys Cemetery
East Providence Cem
Burns Sch
Phillipsdale
Wannamoisett Country Club
Rumford
St Margarets Sch
Thompson Sch
Newman Ave Sch
James V Turner Reservoir
Seekonk High Sch
East Providence Center
Union Sch
Hurst Cem
Wilson Sch
Omega Pond
Radio Towers (WEAN)
Golf Course
TEN MILE RIVER
Radio Tower (WHIM)
Filtration Plant
Pleasant St Sch
Townhall
Jacobs Hill
Mt Carmel Ch
Sewage Disposal
Bullock Point
Tidal Flat
Central
PROVIDENCE CO
BRISTOL CO
PROSPECT STREET
WALNUT ST
NEWMAN AVE
READ ST
MANTON AVE
MONTICELLO RD
BEVERAGE HILL ST
TAUNTON AVE
PIPELINE
BLANDING
WOODWARD
WEST AVE
ARCADE
SCOTT RD
ROGER WILLIAMS
MASSASOIT AVE
CADORNA AVE
DEWEY AVE
METACOMET AVE
TAB AVE
CHESTNUT
LAKE ST
DAVIS
NIMITZ RD
FERRIS
WILSON
GREENWOOD
BROADWAY
Substation
Boys Club



DRAINAGE BOUNDARY
Scale = 1 : 25,000
N
SEEKONK
EAST PROVIDENCE
MASSACHUSETTS
RHODE ISLAND
Seekonk
Luthers Corners
Carpenters Corner
East Providence Center
Armington Corner
Leonard Corner
TEN MILE RIVER
Old Grist Mill Pond
Burrs Pond
Jacobs Hill
Townhall
Golf Course
Radio Towers (WEAN)
Radio Tower (WHIM)
Drive-in Theater
Gate of Heaven Cem
Clear Run
Runnins
Brook

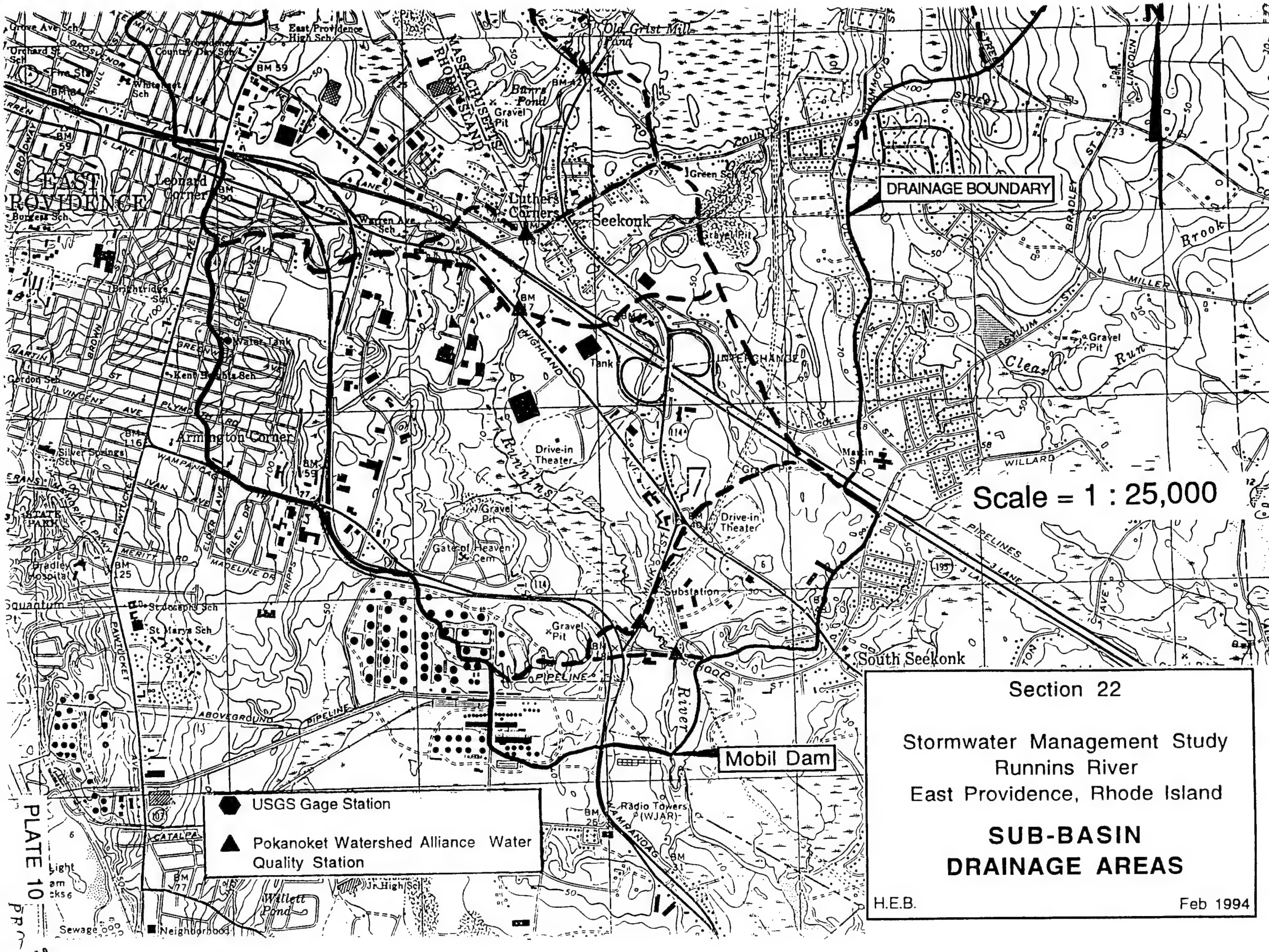
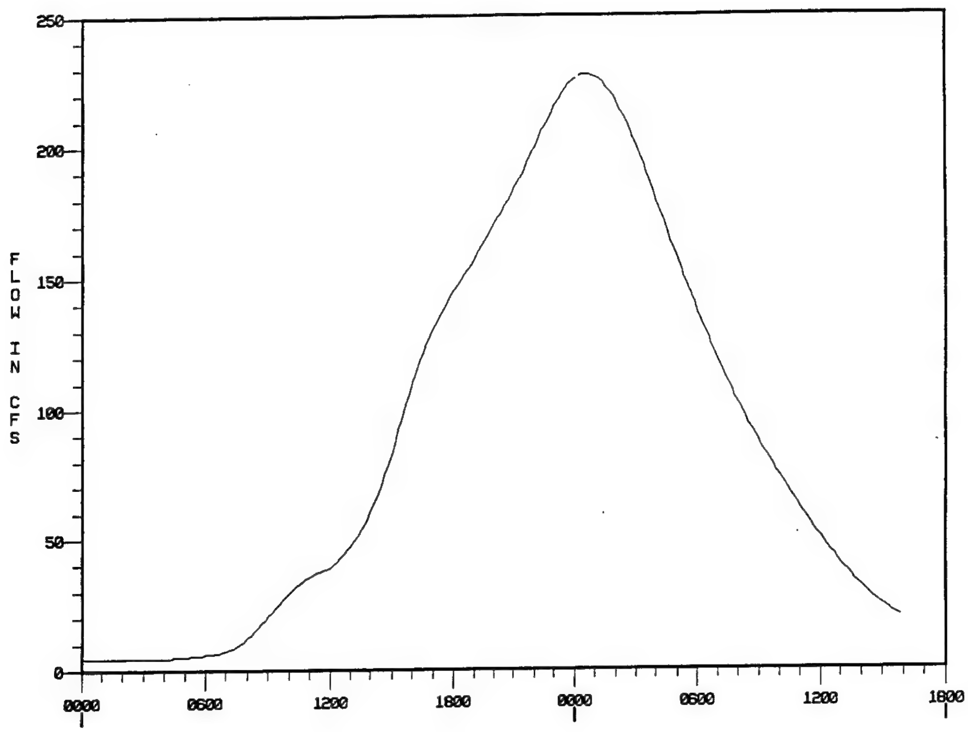
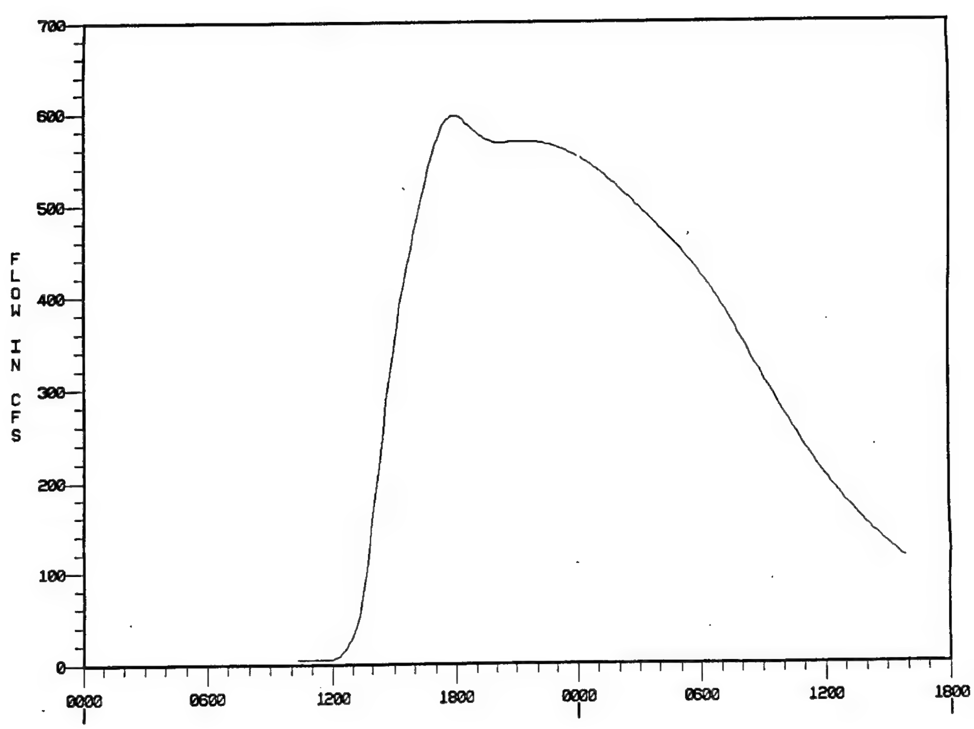

DRAINAGE BOUNDARY
Scale = 1 : 25,000
Mobil Dam
USGS Gage Station
Pokanoket Watershed Alliance Water Quality Station
Section 22
Stormwater Management Study
Runnins River
East Providence, Rhode Island
SUB-BASIN
DRAINAGE AREAS
H.E.B.
Feb 1994
EAST PROVIDENCE
Seekonk
South Seekonk
MASSACHUSETTS
RHODE ISLAND
Runnins
River
Clear Run
Brook
Drive-in Theater
Gate of Heaven Cem
Interchange
Pipelines
Radio Towers (WJAR)
Willett Pond
Luthers Corners
Leonard Corner
Armington Corner

PLATE 10



RUNNINS RIVER AT PLEASANT STREET



RUNNINS RIVER AT THE MOBIL DAM

NOTES:

1. Runoff hydrographs developed using HEC-1 calibrated to the 1979 Flood Insurance Study published by FEMA.

2. A combination of Muskingum-Cunge and Modified Puls routing methods was used

EXISTING CONDITIONS

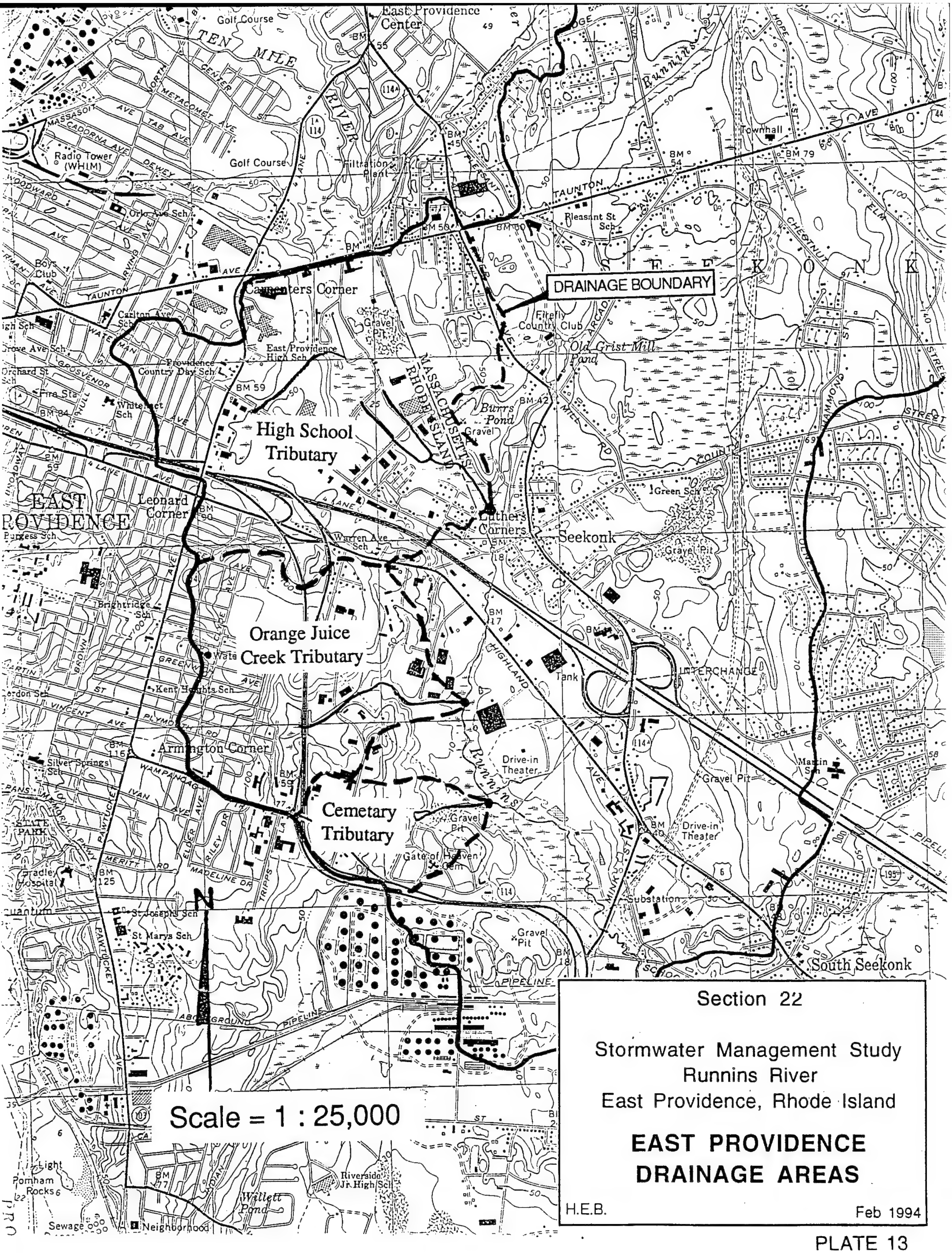
Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

100-YEAR FLOOD HYDROGRAPHS

H.E.B. Feb 1994

PLATE 11



Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

EAST PROVIDENCE DRAINAGE AREAS

H.E.B. Feb 1994

PLATE 13

APPENDIX C

WATER QUALITY ASSESSMENT

APPENDIX C

SECTION 22 PLANNING ASSISTANCE TO THE STATES
RUNNINS RIVER WATERSHED
STORMWATER MANAGEMENT STUDY
EAST PROVIDENCE, RHODE ISLAND

WATER QUALITY ASSESSMENT

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS 02254-9149

JUNE 1994

RUNNINS RIVER WATERSHED
STORMWATER MANAGEMENT STUDY
EAST PROVIDENCE, RHODE ISLAND

WATER QUALITY ASSESSMENT

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<u>List of Photographs</u>

<u>LIST OF PLATES</u>

APPENDIX C

SECTION 22 PLANNING ASSISTANCE TO THE STATES
RUNNINS RIVER WATERSHED
STORMWATER MANAGEMENT STUDY
EAST PROVIDENCE, RHODE ISLAND

WATER QUALITY ASSESSMENT

1. SUMMARY

The Runnins River, a small river with a total drainage area of 10 square miles, is in southeastern Massachusetts and runs along the border with Rhode Island to tidewater in the Barrington River near Hundred Acre Cove. It is rated class B (fishable/swimmable) by Rhode Island and Massachusetts, but fails to meet that classification along its entire length. Principal concerns are high fecal coliform and low dissolved oxygen levels; additional concerns are heavy metals, organic enrichment, algal nutrients, and contaminated sediments. Apparent causes of these problems include a variety of point and nonpoint sources. Although monthly sampling conducted by the Pokanoket Watershed Alliance has identified a number of sources, resulting in abatement of some raw sewage discharges, existing data are not specific enough to definitively identify all sources.

Fecal coliform counts, 25 times the acceptable levels for swimming and 250 times acceptable limits for shellfish harvesting, have been recorded in the lower reach of the Runnins River; and it is strongly suspected the river is a source of high counts in Hundred Acre Cove. High fecal coliform counts in Hundred Acre Cove are of particular concern because they contributed to closing productive shellfish beds. However, it is not clear that the fecal coliform contaminating Hundred Acre Cove come solely from the Runnins River. In addition to the approximately 20 storm drains discharging into the Runnins river, there are approximately 30 storm drains discharging directly into Hundred Acre Cove area. Finally, it is even possible that significant contamination comes up the Barrington River on rising tidal flows. However, this has not been confirmed due to lack of knowledge of mixing and tidal circulation patterns, nor has the original source of these coliform been adequately identified. Sources of bacteria contaminating

the Cove need to be identified before they can be remediated.

Based on review of existing water quality reports and data, a comprehensive nonpoint source pollution study is recommended to identify and quantify nonpoint sources in the watershed. Surface, subsurface, groundwater flow, and soil drainage characteristics of each subbasin should also be investigated. An analysis of tidal interaction with fresh-water runoff from the upper drainage basin is needed to determine whether the Runnins River is the source of contamination of Hundred Acre Cove. A general outline of a sampling program to support the various phases of the nonpoint source pollution study is presented. Specific tasks to confirm estimates of pollutant sources, select alternative remediation measures, and evaluate performance of alternatives will need to be tailored to each phase.

2. INTRODUCTION

a. Purpose. This water quality assessment is an appendix to the Runnins River Watershed Stormwater Management Study. The entire Runnins watershed is evaluated, even though the local sponsor is East Providence, Rhode Island. Assessment is based on a review of water quality investigations conducted by the Rhode Island Division of Water Resources, the Massachusetts Division of Water Pollution Control, the Pokanoket Watershed Alliance citizens' monitoring group, and others.

The purpose of a water quality assessment is to determine whether the water quality standards are either attained or are goals which still need to be achieved. In addition, a water quality assessment can determine whether present conditions need to be restored, either in the watershed or in impacted downstream areas. Because the Runnins River flows into tidewater and tidal flushing has important effects on water quality in Hundred Acre Cove, an understanding of tidal hydraulics is also necessary.

States categorize waters according to water use classification based on considerations of public health, recreation, propagation of fish, shellfish, and wildlife, and economic and social development. Any water whose quality falls below any criteria corresponding to its classification is considered in violation of its water quality standards and unsatisfactory for the uses indicated in that class. Once a picture of water quality emerges, it is necessary to evaluate what can be done to reach water quality objectives. This requires an evaluation of known

pollution sources and review of stormwater and wastewater management plans to assess what is being done to control pollution.

This information is provided in the context of existing and evolving stormwater management programs. U.S. Environmental Protection Agency (EPA) programs for National Pollution Discharge Elimination System (NPDES) permits already control the quality of runoff from construction and industrial sites, and municipal stormwater systems of large cities. Extension of the municipal program to small and medium cities is scheduled under Phase II. Also anticipated is State implementation of the Coastal Nonpoint Pollution Control Program required under Section 6217, "Protecting Coastal Waters," of the Coastal Zone Act Reauthorization Amendments of 1990.

b. Study Area. The Runnins River watershed is located in the eastern part of East Providence, RI., and the western portion of Seekonk, MA., and northwestern portion of Rehoboth, MA., see plate 1. East Providence is a medium sized city, immediately east of Providence, RI., on the eastern side of Narragansett Bay. It borders Barrington, RI. on the south, Seekonk, on the east, and Pawtucket, RI., on the north.

The Runnins River's 10-square mile watershed is part of the approximately 40-square mile Warren River watershed located in the Narragansett Bay coastal drainage area. Major watersheds draining into Narragansett Bay are the Taunton, Blackstone, and Pawtuxet Rivers (see plate 2).

c. Background. Not only is there public concern about water quality degradation in the Runnins River, but also adverse effects on receiving waters of the Runnins and Barrington Rivers. Poor water quality has been a documented problem in the lower Runnins River since the 10-11 August 1966 field investigation by the Rhode Island Department of Health (RIDOH), which showed very poor water quality in the lower river, with DO levels ranging close to depletion, and coliform levels ranging up to those found in raw domestic wastewater.

Fecal coliform monitoring conducted by the Pokanoket Watershed Alliance from June 1992 to December 1993 show that more than one-half of monthly Runnins River samples exceed the class B standard. At many stations, samples exceed even the Massachusetts class C variability criteria. Other investigators show low dissolved oxygen, high chemical oxygen demand, moderately high levels of nutrients, and

elevated levels of metals and organic compounds in sediments.

Fecal coliform levels in the river are perceived to have directly contributed to elimination of shellfishing activities downstream in Hundred Acre Cove. Closing of the shellfish beds was a major reason local citizens' groups pushed for involvement of the New England Interstate Water Pollution Control Commission in study of the river. In the cove, 75 percent of PWA samples exceed the class SA standard for shellfish harvesting, which is much stricter than the class B standard for swimming in the river.

From 1990 to 1993, bacterial contamination resulted in the Hundred Acre Cove area being classified as conditionally closed to shellfish harvesting at least seven days following a 24-hour 0.5-inch or more rainfall. In addition, the larger shellfish growing area bounded by the Barrington, Palmer, and Warren Rivers was closed seven days following a 1-inch rainfall, due to combined sewer outfall (CSO) discharges to the Providence and Seekonk Rivers in Upper Narragansett Bay. This resulted in closing the cove for 50 to 70 percent of the year. Finally, in May 1993, the cove was reclassified as prohibited for shellfish harvesting, based on bacteria levels exceeding national shellfish sanitation program criteria for both dry and wet weather monitoring.

d. <u>Watershed Description</u>. The Runnins River has a total drainage area of 9.87 square miles at the Mobil dam, which is the normal upper limit of tidewater and 1,000 feet upstream from confluence with the Barrington River. Elevations in the basin range from a maximum of 200 feet NGVD at Great Rock, near the headwaters in Rehoboth, MA., to sea level at the confluence of the Runnins River with the Barrington River in Hundred Acre Cove in Barrington, RI. Wetlands in flat areas and scattered hills prevail in the upper basin, but there are no major water bodies in the basin. Approximately five small ponds and 10 small streams connect directly to the Runnins River. Interstate Route 195, U.S. Routes 6 and 44, and State Routes 114 and 114A traverse the basin; their interchanges connect local streets. Fourteen bridges cross the main stem of the Runnins River, which flows over the Grist Mill Pond dam above Fall River Avenue and the Mobil dam below School Street.

Headwaters of the Runnins River watershed are in Rehoboth, but the actual river begins in Seekonk, MA. The river flows generally southwesterly through Seekonk, and

after about five miles, becomes the State border between Seekonk and East Providence. Here, the river turns southward, flowing in a southerly and southeasterly direction to the Mobil dam. Downstream of the dam, the Runnins enters the Barrington River.

The upper watershed of the Runnins River is relatively undeveloped, with only small residential areas, and numerous wetlands and forested areas. Upstream of a USGS staff gage at Pleasant Street (drainage area of 4.24 square miles), the average river slope is 11 feet per mile for its 4.2-mile length. According to the hydrologic analysis, about one quarter of the watershed area provides runoff storage during rainfall events, either in wetlands or a series of ponds (Hydrologic Appendix B).

Downstream of Mobil dam, the watershed changes character. East Providence, on the western border of the watershed, is a mature, urbanized area, while western Seekonk, on the eastern side, is rapidly developing, with increasing impervious areas and runoff rates. A large wetland area downstream of Pleasant Street provides substantial storage (Hydrologic Appendix B).

The Mobil dam was constructed in the 1920s to collect boiler and process water from the river (Mobil Comprehensive Site Assessment Work Plan, 1994). Secondary effects of the dam were creation of a freshwater pool, elimination of mud flats, protection of low areas in East Providence from normal high tides, and maintenance of fairly constant river water levels, with subsequent stabilization of the groundwater table in adjacent areas.

Freshwater flow continues past the dam, down the Barrington River into Hundred Acre Cove. Downstream from the dam, the Barrington River is generally tidally influenced. The slope is relatively flat, and direction and rate of flow depend on tidal movement. About 4 miles downstream from Hundred Acre Cove, tidal extension of the Barrington River discharges into Upper Narragansett Bay immediately above Smith Cove (see plate 3).

e. <u>Tidal Hydrology</u>. Mobil dam is generally considered the end of Runnins River and the beginning of tidewater. In order to determine how often tidal elevations will exceed the spillway crest of Mobil Dam, allowing saltwater into Runnins River, tidal hydrology needs to be understood. Tidal inundation affects water quality by introducing salt into the river and possibly causing density stratification behind the dam. It is also important to understand tidal

hydrology because it affects tidal flushing in Hundred Acre Cove, which is an important factor in its water quality.

(1) General. The location nearest Mobil dam where tidal datum is available is Warren, RI., which is 2.5 miles southeast of the dam and below confluence of the Palmer and Barrington Rivers. However, tidal information developed at Warren will only approximate that in the Runnins River because constrictions in the Barrington River can affect the amplitude of the tidal storm surge. Although funneling effects can cause maximum tidal elevations to increase going up river, generally they decrease in that direction.

Although rapid tidal currents in the Barrington River can shift the time of occurrence and height reached by the tide at Hundred Acre Cove, a range of tide similar to that at Warren is assumed for preliminary analysis. The mean range and mean spring range of tides for Warren, shown in table C-1, are 4.6 and 5.7 feet, respectively. Maximum and minimum predicted astronomic tide ranges of about 8.8 and 1.4 feet, respectively, shown on plate 4, were estimated by applying probability factors given in Coastal Engineering Research Center Special Report 7 (Harris, 1981) for Newport Harbor to the subordinate station at Warren.

The total effect of astronomical tide combined with storm surge produced by wind, wave, and atmospheric pressure contributions is reflected in actual tide gage measurements.

The New England Coastline Tidal Flood Survey was developed in September 1988 by statistical determination of tidal stage-frequency relationships at various gaged points along Narragansett Bay, and use of historical high watermark data at intervening points. A location map and profile, for the reach where the study is located, are shown on plates 5 and 6, respectively. Using this survey, tide stages for various return periods at Rumstick Point, Barrington, and mouth of Warren River, Warren, R, were estimated and are shown in table C-2.

During mean spring high water (MHWS) and mean high water (MHW), the Mobil dam, with an estimated spillway crest elevation of 4.5 feet NGVD (Hydrologic Appendix B), is the upstream limit of tidal influence. Once a year, the dam will be overtopped by maximum predicted astronomical high water, and storm events equal to or greater than the 1-year return period storm are also expected to overtop the dam.

Depending on the storm duration, significant amounts of saltwater could get into the Runnins River. As a point of reference, the streambed crosses the contour elevation 10 feet NGVD approximately 1.3 miles upstream of the Mobil dam.

TABLE C-1

WARREN, RHODE ISLAND
TIDAL DATUM PLANES
NATIONAL OCEAN SURVEY TIDE GAGE
(Based Upon 1960-78 NOS Tidal Epoch)

	Tide Level (ft, NGVD)
Maximum Predicted Astronomical High Water	5.3
Mean Spring High Water (MHWS)	3.4
Mean High Water (MHW)	2.9
Minimum Predicted Astronomical High Water	1.3
Mean Tide Level (MTL)	0.6
National Geodetic Vertical Datum (NGVD)	0.0
Maximum Predicted Astronomical Low Water	-0.1
Mean Low Water (MLW)	-1.7
Mean Spring Low Water (MLWS)	-2.2
Minimum Predicted Astronomical Low Water	-3.5

TABLE C-2

ESTIMATED FREQUENCY
OF TIDE STAGES AT
RUMSTICK POINT, WARREN RIVER MOUTH,
BARRINGTON AND WARREN, RHODE ISLAND

Return Period (years)	Stillwater Tide Elevation (ft, NGVD)
100	14.4
50	13.2
10	7.9
1	5.0

(2) Hundred Acre Cove

(a) General. Hundred Acre Cove is located in the Barrington River below Mobil dam. It is considered a significant part of the commercial quahog shellfish industry and has been designated part of Shellfish Growing Area 2 by the State of Rhode Island. One of the three largest salt marshes in the State, it has been designated by EPA as a priority wetland. It provides habitat for rare birds and the Northern Diamond-backed Terrapin, a threatened species whose habitat may range up the Runnins River.

In Hundred Acre Cove, freshwater from the Runnins River and drainage from the cove's watershed mix with and dilute seawater. Based on limited salinity readings by the Pokanoket Watershed Alliance, the saltwater-freshwater transition zone normally begins below the Mobil dam, but at times may extend upward into the Runnins River. Mixing, turbidity, salinity, stratification, and water circulation patterns in Hundred Acre Cove have not been determined. Water quality and sediment investigations performed by the Narragansett Bay Project, in conjunction with the National Estuary Program did not extend beyond the main channel of the bay and mouths of some rivers; and the Warren River was not sampled.

Current sampling in the Runnins River and Hundred Acre cove is limited to grab samples, collected independently of travel time between stations or tide level in the cove. This sampling effort is too simplistic to determine whether water quality problems originate in the upper watershed and are brought down the river, or originate below Mobil dam and come in with the tide. Sampling over selected storm hydrographs, with sampling time at stations correlated to travel time, and gaging of streamflow and tidal flux, would be more useful in addressing whether the Runnins is the major contributor to problems in the cove.

(b) Tidal Flushing. The surface area of the Hundred Acre Cove decreases from 450 acres at mean high water to 250 at mean low water. Assuming a 6-hour period between mean high water and mean low water, a cursory upper bound estimate of average tidal flux is 4,100 cubic feet per second (cfs) between the Mobil dam in East Providence and Massasoit Avenue in Barrington, R. This is more than two orders of magnitude greater than the annual mean flow of 21.5 cfs at School Street, and one order of magnitude greater than the 2-year computed peak flow of 205 cfs at the Mobil dam (Hydrologic Appendix B).

Most mixing and flushing of the cove depends on tidal action. Freshwater mixing is expected to be rather limited in the eastern part of the cove below the spit of land known as "The Tongue," which separates the deeper part of Hundred Acre Cove from the main channel. Direction and quantity of flow in the Barrington River depend more on diurnal and periodic variation of the tides over the 5.5-mile length between Upper Narragansett Bay and Hundred Acre Cove than on freshwater inputs from coastal drainage and the Runnins River.

3. WATER QUALITY CLASSIFICATIONS

a. Freshwater Classification. The entire Runnins River is designated a class B warm water fishery according to water quality standards of both Rhode Island (RIGL 46-12) and Massachusetts (314 CMR 4.00). This classification represents a goal for the water body, and does not indicate that the water meets this standard. Class B waters are suitable for bathing and other recreational purposes; protection and propagation of fish, other aquatic life and wildlife; and, after adequate treatment, for use as water supplies.

Massachusetts class B standards require a minimum dissolved oxygen (DO) concentration of 5.0 mg/l for warm water fisheries, pH in the range of 6.5 to 8.0 standard units or as naturally occurs, fecal coliform not to exceed a geometric mean of 200 organisms per 100 ml in any representative set of samples, nor shall more than 10 percent of the samples exceed 400 organisms per 100 ml, and color, turbidity, and suspended solids in concentrations that do not exceed recommended limits of the most sensitive receiving water use. Also, the waters shall be free of floating oils, grease, and petrochemicals, and pollutants that form objectionable deposits or nuisances (see plate 7 for Class B reach).

Rhode Island class B standards require a minimum DO concentration of 5.0 mg/l for warm water fisheries, pH in the range of 6.5 to 8.0 standard units or as naturally occurs, fecal coliform not to exceed a median value of 200 per 100 ml, and not more than 20 percent of the samples shall exceed a value of 500 per 100 ml, and color and turbidity concentrations not to exceed a level that impairs any uses in this class. The waters in this class must also be free of floating oils, grease, petro-chemicals, and any pollutants that form objectionable deposits or nuisances.

b. Saltwater Classification. The Barrington River is rated class SA by Massachusetts from its source, in a marsh in South Seekonk, MA, to the State border. From the State line, approximately 1,000 feet downstream from the Mobil dam, to the railroad bridges approximately 1,000 feet above its confluence with the Palmer River in Warren, R, classifies the Barrington River as class SA (see plate 8 for class SA reach).

From 1,000 feet above the confluence with the Palmer River to a line drawn between Adams and Jacobs Points, the Warren River is rated class SC in a 0.9 mile long segment and SB in the remaining 1.5 miles. At Smith Cove on Rumstick Neck, the Warren River discharges into Upper Narragansett Bay, a 16-square mile part of the 147 square mile water surface of the Narragansett Bay estuary. Upper Narragansett Bay is rated class SA.

Water quality standards for saltwater areas are different from the freshwater standards. Saltwater in which shellfishing is allowed has the most stringent water quality standards. The goal for class SA waters is suitability for shellfish harvesting for direct human consumption, bathing and contact recreation, and fish and wildlife habitat. The goal for class SB waters is suitability for shellfish harvesting after depuration, bathing and primary contact recreation, and fish and wildlife habitat. Class SC waters have a goal of suitability for boating and other secondary contact recreational activities, fish and wildlife habitat, industrial cooling, and good aesthetic value.

Massachusetts class SA standards require a DO concentration of 6.0 mg/l at any place or time except as naturally occurs, pH in the range of 6.8 to 8.5 standard units or as naturally occurring, and fecal coliform not to exceed a geometric mean MPN of 14 organisms per 100 ml, nor shall more than 10 percent exceed a MPN of 43 per 100 ml in waters approved for open shellfishing. In waters not designated for shellfishing, fecal coliform shall not exceed a geometric mean of 200 organisms in any representative set of samples, nor shall more than 10 percent of the samples exceed 400 organisms per 100 ml.

All Rhode Island saltwater standards call for color, turbidity, and temperature not to exceed levels that impair any uses. Waters must also be free of floating oils, grease, and petrochemicals, as well as any pollutants that form objectionable deposits or nuisances. Specific criteria exist for dissolved oxygen (DO), fecal coliform, and pH.

Rhode Island class SA standards require a DO concentration of 6.0 mg/l at any place or time except as naturally occurs, pH in the range of 6.8 to 8.5 standard units or as naturally occurring, and fecal coliform not to exceed a median value of 15 colonies per 100 ml, with not more than 10 percent of the samples exceeding a value of 50 colonies per 100 ml.

c. Shellfish Certification. Prior to Rhode Island approval of an area as a shellfish source, a sanitation survey is required in accordance with national shellfish certification program guidelines. Following the survey, the area is classified as approved, conditionally approved, restricted, conditionally restricted, or prohibited. Criteria for meeting the approved classification include the following:

(1) The fecal coliform median cannot exceed 14 per 100 ml, and not more that 10 percent of the samples can exceed a most probable number (MPN) of 49 colonies per 100 ml (for a 3-tube decimal dilution test).

(2) The total coliform median of the water cannot exceed 70 per 100 ml, and not more than 10 percent of the samples can exceed an MPN of 220 per 100 ml (for a 3-tube dilution test).

Rhode Island designated the area bounded by the shorelines of the Barrington (which includes Hundred Acre Cove), Palmer, and Warren Rivers as Shellfish Growing Area 2 (shown on plate 9). In the most recent Barrington, Palmer, and Warren Rivers Shoreline Survey and Reappraisal Report, prepared by RIDEM Division of Water Resources in the spring of 1990, Hundred Acre Cove, which is in the uppermost portion of the area, was rated class SA, conditionally approved, for harvesting of shellfish for direct human consumption.

Neither the Palmer nor Barrington Rivers north of the railroad bridges meet the conditionally approved rating established by the Spring 1990 report. In addition, harvesting of shellfish for direct human consumption has been prohibited since 1990 in the Palmer River, and since May 1993, in the Barrington. Rhode Island does not have a depuration program.

d. Groundwater Classification. Groundwaters in the East Providence portion of the Runnins River watershed currently have been classified GB, with small portions as GA. The Rhode Island Groundwater Protection Act of 1985

(46 RIGL 13.1) classifies groundwater sources based on suitability for public or private drinking water. Class GA groundwater sources are of high quality, and suitable for drinking without treatment. Class GB groundwater sources are unsuitable for drinking without treatment because water quality degradation is known or presumed.

Groundwater in the Seekonk and Rehoboth, MA portions of the Runnins River watershed are designated by the Commonwealth of Massachusetts Ground Water Quality Standards (314 CMR 6.00) as class I, and suitable as a source of potable water without treatment. As such, groundwater should be free of fecal coliform.

4. EXISTING WATER QUALITY CONDITIONS

a. General. A number of surveys have been conducted within the last several years to determine water quality conditions within the Runnins River Basin. Various State agencies collected and analyzed water from the river and a few sediment samples have also been examined. Since 1990, the Pokanoket Watershed Alliance has been especially active and conducted monthly, and at times more frequent, water quality sampling of the Runnins River. Mainly, the studies show fecal coliform as a serious problem, entering the Runnins River in large numbers even during dry weather. The following sections summarize, in chronological order, water quality studies in the river at the time of sampling.

b. State of Rhode Island - Department of Health, 1966. In late summer 1966, the Rhode Island Department of Health (RIDOH) sampled the Runnins and Barrington Rivers during a dry weather period. Runnins results showed very poor water quality, with DO levels close to depletion, and coliform levels ranging up to those found in raw domestic wastewater. These conditions indicate possible cross connections of sanitary lines to storm sewers, or severely overloaded individual wastewater disposal systems. The Barrington River showed better conditions, particularly with respect to coliform bacteria. It is not clear whether this improvement was due to dilution, or if the Barrington River station was sampled before the poor quality water from the Runnins had arrived.

On 10-11 August 1966, RIDOH collected grab samples on 2-hour intervals from the Runnins River in East Providence at Warren Avenue (U.S. Route 6) and Mink Street approximately 2,000 feet upstream of the Mobil dam), and from the Barrington River from both the Barrington and Warren sides of the County Road Highway bridge (State Routes 103/114).

Grab samples were analyzed for temperature, dissolved oxygen, and percent saturation. Every third grab sample was analyzed for coliform. Also, a total of eight samples were composited on 4-hour intervals at each station. Runnins River composites were analyzed for odor, turbidity, hardness, alkalinity, pH, detergents, and 5-day biochemical oxygen demand (BOD_5). Barrington River composites were analyzed for the same parameters, except hardness and detergents, plus chloride.

Sampling was performed during dry weather conditions. On 10-11 August, 0.01 inch of rain fell each day. The only previous rain for the month was 0.12 inch on 2 August. Total precipitation of 2.77 inches in July was 0.14 inch below normal (NOAA climatological data, Weather Station Observatory at Providence Airport).

(1) <u>Runnins River</u>. DO concentrations ranged from 0.4 to 2.6 mg/l at Warren Avenue and 0.4 to 6.9 mg/l at Mink Street, where only one-third of the samples met or exceeded the minimum class B limit of 5.0 mg/l. In a 24-hour period, with temperatures ranging from 68 to 74 degrees Fahrenheit, percent DO saturation varied from 4 to 30 percent at Warren Avenue, and 4 to 80 percent at Mink Street. These results do not meet class B standards, which require 75 percent saturation at least 16 hours per day. The pH was within the acceptable range.

At Warren Avenue, coliform ranged from 23,000 to 230,000 per 100 ml. At Mink Street, the range was from 2,300 to 230,000 per 100 ml. Both the minimum and maximum values exceed class B water quality criteria. Detergent concentrations did not exceed 0.10 mg/l as ABS. Average alkalinity and hardness concentrations were 48 and 112 mg/l, respectively, at Warren Avenue; and 65 and 90 mg/l, respectively, at Mink Street; these are typical levels for New England streams.

BOD_5 concentrations ranged from 2.0 to 6.0 at Warren Avenue and 1.4 to 2.1 mg/l at Mink Street. BOD_5 values above 2.0 mg/l are indicative of polluted water (MADEP-DWPC, February 1987). Average turbidity values at Warren Avenue and Mink Street stations were 11 and 22, respectively. An oily odor was detected at Mink Street but not at other stations.

(2) <u>Barrington River</u>. In a 24-hour period, with temperatures ranging from 71 to 78 degrees Fahrenheit, percent DO saturation varied from 43 to 77 percent at the Warren side, and 44 to 80 percent at the Barrington side of

the County Road Highway bridge. DO concentrations ranged from 3.0 to 5.5 mg/l. None of the composite samples from the Barrington River met the minimum DO concentration of 6.0 mg/l required to meet class SA standards. The pH range was normal between 7.1 and 7.3.

BOD_5 concentrations ranged from 1.8 to 6.4 mg/l at these stations. Turbidity values averaged between 9 and 10. Coliform ranged from 23 to 230 colonies per 100 ml. Only two values exceeded current class SA water quality criteria for total coliform. At the Barrington River County Road Highway bridge sampling stations, average alkalinity was 88 mg/l and average chloride was 16,100 mg/l; these levels are typical of the brackish conditions expected for this part of the river.

c. Facilities Plan for Wastewater Management--Draft, Seekonk, Massachusetts, 1981. In 1979 and 1980, as part of the town of Seekonk's wastewater facility planning process, Keyes Associates performed groundwater and surface water sampling townwide, including the Runnins River watershed. The Runnins River surface water quality was sampled four times each at three stations: Ledge Road, Luthers Corner, and School Street. Samples were analyzed for total phosphate, nitrate, nitrite, ammonia, chloride, and fecal coliform. Results were typical of New England streams in urban watersheds.

Fecal coliform levels ranged from 1 to 460 per 100 ml, with highest levels at School Street. Total phosphate levels ranged from 0.05 to 0.27 mg/l. Nitrate levels ranged from 0.5 to 2.0 mg/l, and nitrite levels were less than 0.02 mg/l (as nitrogen). Ammonia levels ranged from 0.05 to 2.1 mg/l (as nitrogen). Chloride levels ranged from 8.8 to 102 mg/l. The summary of draft Facility Plan recommendations is shown in section 7b.

d. Rhode Island Department of Environmental Management (RIDEM), Division of Water Resources--USGS, 1988-1989. Between 1988 and 1989, the USGS analyzed 45 general water quality parameters in Rhode Island rivers for the RIDEM Division of Water Resources' nonpoint source assessment program. Results showed the Runnins River to have some of the poorest water quality among the fifteen rivers sampled.

(1) Study Design. RIDEM and the USGS jointly designed the study to obtain general water quality data for rivers with little data. The intent was to obtain data representative of both wet and dry flow conditions. The study yielded a total of approximately 64 data points for

each parameter, except metals which were not analyzed as often. Results were published in Appendix C of Rhode Island's 1990 Report to Congress on the State's waters under section 305(b) of the Clean Water Act.

In 1988, 15 rivers were sampled once in the spring and again in the summer; nine were sampled at only one station, and the other four, at two stations. In 1989, 11 rivers were sampled once each in spring and summer. Nine rivers were sampled at only one station, the other two at two stations. Of the rivers sampled in 1988, only four were sampled again the following year, with the Runnins sampled a total of six times. In April and July 1988 and 1989, the river was sampled at Fall River Avenue, Seekonk, MA (State Route 114A), approximately 10 feet downstream from the bridge below the Grist Mill Pond outlet. A second station was sampled in May and July 1989 at South Seekonk, on the upstream side of the School Street bridge. This study is very useful in comparing dry and wet weather flow conditions, and representative results are included in table C-3. The estimated monthly mean flow rates (Hydrologic Appendix B) and antecedent weather conditions (NOAA climatological data for Providence, R), are also included in table C-3 for use in further analysis of water quality data from this sampling effort.

(2) Study Results. Results show that the Runnins River is among the most polluted rivers in the study, in terms of low dissolved oxygen concentration, and high chemical oxygen demand, solids residue, and color. Of all results from the entire study, the South Seekonk 27 July 1989 sample (7.4 cfs flow rate) showed the lowest concentration and percent saturation of dissolved oxygen. DO ranged from 4.2 to 11.6 mg/l and 49 to 98 percent saturation in the Runnins River samples.

The second highest values for chemical oxygen demand, solids residue, and color were found in the Runnins River, which also had the third highest concentration of ammonia-nitrogen and organic nitrogen and was in the middle of the pack for other nitrogen parameters and phosphorus.

TABLE C-3

RUNNINS RIVER

FLOW AND REPRESENTATIVE WATER QUALITY DATA FROM 1988-1989 RIDEM-USGS WATER QUALITY SAMPLING PROGRAM

Sources: Hydrologic Appendix B, NOAA climatological data, and 305(b) Report to Congress, RIDEM 1990

	At Fall River Avenue, Seekonk MA				At School Street, Seekonk MA	
	April		July		May	July
Estimated Mean Monthly Flow, cfs	20		3.5		19	4
Year	1988	1989	1988	1989	1989	1989
Month-Day	4-21	4-25	7-26	7-27	5-18	7-27
Instantaneous Flow, cfs	5.8	9.9	5.2	2.9	19	7.4
Antecedent Rainfall, Date	0.07" 4-18	0.01" 4-19	1.43" 7-24	3.23" 7-17	0.05" 5-17	3.23" 7-17
Rainfall in previous 7 days	0.18"	0.04"	4.53"	0.24"	1.78"	0.24"
Specific Conductivity, microsiemens/cm	155	145	227	164	334	437
Chemical Oxygen Demand, mg/l	14	55	43	52	31	32
Fecal Streptococci, colonies/100 ml	110	260	1,330	1,800	84	870
Solids Residue, mg/l	102	110	179	126	212	247
Dissolved Chloride, mg/l	20	18	21	21	67	93

The Runnins had the second highest manganese concentration, but otherwise average metals concentrations. Coliform counts were high in Runnins River samples compared to state standards. However, bacteria counts were high in other rivers sampled as well, and Runnins River levels were neither at the high nor the low end of the group.

RIDEM discontinued its contract with USGS, and now contracts with the University of Rhode Island and Roger Williams College to conduct baseline chemical and biological monitoring on rivers and streams. The Runnins River is not currently included in this sampling program. Although subject to intense monitoring by the PWA and others, the Runnins may not be easy to include in comparative analyses if data collection and analysis are not standardized with the Statewide program.

e. Shellfish Growing Area Monitoring, 1990-1993. Rhode Island's Shellfish Growing Area Monitoring Program conducts continuous bacteriological monitoring of the State's harvesting waters to maintain certification for shellfish harvesting for direct human consumption under the U.S. FDA's National Shellfish Sanitation Program (NSSP). Hundred Acre Cove is located in Growing Area 2, which includes the entire Barrington, Palmer, and Warren Rivers. The State uses the fecal coliform as a standard, but also analyzes total coliform so that overall trends can be analyzed.

Sampling runs are conducted monthly during dry weather periods, when conditionally approved portions of the Barrington, Palmer, and Warren Rivers are open to shellfish harvesting. RIDEM defines a dry weather period as greater than seven days after a rainfall or snowmelt event of 0.5 inch or more, or a wastewater treatment plant bypass of 0.5 million gallons or more into Upper Narragansett Bay. Sampling runs may also be conducted during wet weather periods, but on a more infrequent and random basis (see plate 10 for sampling locations).

The most recent Shoreline Survey Reappraisal Report for the Barrington, Palmer, and Warren Rivers was prepared by RIDEM, Division of Water Resources in the spring of 1990. The area was first surveyed in July 1986, and an update of the 1990 report is in progress. The 1990 report expresses concerns about bacteriological degradation of upper portions of the Barrington and Palmer Rivers, based on statistical evaluation of compliance monitoring data, which represents only sampling during dry weather periods.

This dry weather data demonstrates that the total coliform median value criterion for class SA waters is exceeded at the Hundred Acre Cove station nearest the mouth of the Runnins (station 1). The fecal coliform median value is at the upper class SA limit, although variability criteria conform with the class SA standard. The report indicates bacteria loadings originate in the Runnins River watershed, and that the source may be constant and not wet weather dependent (RIDEM, Shoreline Survey, 1990).

Further downstream in Hundred Acre Cove, station 1A, located approximately midway between stations 1 and 3, conforms to all criteria for class SA water. Whereas, station 3, located in the Barrington River downstream from station 1A, slightly exceeds the fecal coliform median criteria, but conforms to total coliform median as well as all variability criteria. Elevated coliform counts at station 3 indicate a possible source in the Hundred Acre Cove itself, or that coliforms are being brought up the Barrington River by tidal inflows. Therefore, further statistical and field investigations are warranted to identify possible sources including Hundred Acre Cove, Runnins River, and the Barrington and Palmer Rivers by flood tides (RIDEM, Shoreline Survey, 1990).

f. <u>RIDEM 305(b) Reports, 1990 and 1992</u>. Based in part on the USGS-RIDEM and shellfish growing area monitoring programs, RIDEM assessed the Runnins and Barrington Rivers, upstream from the railroad bridge north of the Route 114 bridge, as fishable and swimmable, but water quality impaired by nonpoint source pollution. This assessment was contained in the 1990 Report to Congress on the State of the State's Waters, under section 319(b) of the Clean Water Act. Causes and sources of poor water quality were identified as bacterial inputs from runoff and storm sewers, highway runoff, land disposal, and onsite waste treatment. The 2.3 miles of the Runnins River in Rhode Island were also reported as not meeting class B water quality standards for minimum DO and maximum fecal coliform counts. The 5 miles of the upper Barrington were found to only partially support its class SA water quality goal for maximum fecal coliform. The upper area of the Barrington River was described as under severe threat of not attaining water quality goals due to high bacterial levels, which could result in shellfish closures (RIDEM, 1990).

The 1992 report stated the swimmable goal was partially supported, and nonattainment of the fishable goal was threatened in the class SA rated Barrington River. Deterioration of the Runnins River was described as a

significant threat to the upper Barrington River/Hundred Acre Cove area because it appeared that contamination of shellfish beds was caused by pollutant loadings from runoff to the Runnins River during wet weather; however, significant high fecal counts also occurred in dry weather (RIDEM 305b, 1992 and MADEP Technical Letter, 1991). RIDEM intends to base future assessments of the Runnins River on results obtained from studies coordinated by the New England Interstate Water Pollution Control Commission (NEIWPCC), such as water quality monitoring by the Pokanoket Watershed Alliance (RIDEM 305b, 1992). Because of its financial support of NEIWPCC sampling efforts, RIDEM did not include the Runnins River in Statewide chemical and biological monitoring programs.

g. MADEP Water Quality Survey, 1991 and 1992. The Technical Services Section of the Massachusetts' Department of Environmental Protection (MADEP) conducted water column sampling on 19 June and 18 July 1991, and sediment sampling in June 1992. Dates were preceded by notably dry weather. Results showed poor water quality conditions including low dissolved oxygen, high fecal coliform counts, and significantly elevated nitrogen levels. Sediment contamination problems were identified at some sites. Sampling for wet weather conditions is planned for the future.

Survey results, discussions, and conclusions were reported in technical memoranda dated 31 January and 19 October 1992. These reports discussed characteristics of the Runnins River watershed, potential sources of both point and nonpoint pollution, available background information, and public concern about the river's critical role in determining the shellfishing status in Hundred Acre Cove. Additionally, they summarized septic system corrective actions, requirements for new leaching fields, and hazardous waste sites for cleanup, identified by MADEP's Bureau of Waste Site Cleanup, in the town of Seekonk. The surveys describe biological and physical-chemical effects that may play a role in water quality in the Runnins River, such as wetland processes and sediment chemical oxygen demand, and recommend comparing sediment results to contaminant standards. Also recommended are wet weather sampling, biological testing, analysis of sediment results, and dye tests to identify septic system impacts.

Massachusetts' 1992 Summary of Water Quality Report identifies all 3.7 miles of the Runnins River in Massachusetts as not supporting water quality goals for a class B warm water fishery. Causes are organic enrichment,

nutrients, oil and grease, and pathogens from urban runoff, storm sewers, and natural sources.

(1) <u>Dry Weather, Water Column Analyses</u>. Samples were collected from two sites on 19 June and ten sites on 18 July 1991. Dry weather preceding the sampling dates made for ideal conditions (Technical Memorandum, MADEP-DWPC-TSS, 31 January 1992). According to NOAA climatological data collected at the Providence Airport, total precipitation of 0.93 inch in June was 1.86 inches less than normal, and total precipitation of 2.76 inches in July was 0.72 inch less than normal. Ten to 12 sampling stations were chosen to include instream locations, as well as storm drains and tributaries on the Massachusetts side; no attempt was made to sample storm drains entering from the East Providence side. Between extreme stations at the downstream side of Taunton Avenue (U.S. Route 44) bridge and the upstream side of School Street bridge, the following sites were sampled: Pleasant Street and a storm drain at this location, Burr's Pond outlet, Grist Mill Pond outlet at Fall River Road (State Route 114A), Highland Avenue (U.S. Route 6) bridge crossing, a storm drain and unnamed tributary at this location, a storm drain at Mink Street, and the upstream side of Mink Street. For general location of sampling sites, see plates 1 and 11.

One-half of the ten 19 June fecal coliform levels and 80 percent of the ten 18 July levels exceeded the class B standard. The highest instream level, 2,200 coliforms per 100 ml, occurred on 18 July below the Grist Mill Pond dam. The next highest instream levels of 1,040 and 920 per 100 ml, on 19 June and 18 July, respectively, were found at Pleasant Street; and 960 per 100 ml was found on 18 July, below Highland Avenue, downstream from two storm drains with high levels. On 19 June, fecal coliform levels were five times greater than the class B limit of 200 per 100 ml at the most upstream instream station, Pleasant Street; 1.4 times greater at the Grist Mill Pond outlet; 2.3 times greater at Highland Avenue; equalled the allowable limit at Mink Street; and were 1.5 times greater at School Street. On 18 July, fecal coliform levels were four times greater than the class B limit of 200 per 100 ml at the two most upstream instream stations, 11 times greater at the Grist Mill Pond outlet, and 10 times less than the allowable limit at the Burr's Pond outlet, but increased by a factor of 30 between Burr's Pond and the Highland Avenue sampling station to a value three times the allowable limit; and equalled the allowable limit at Mink Street.

Nitrogen and phosphorus levels were well within the range found in other New England streams in reaches with ratios of wetland area to drainage area varying from 1 to 24 percent (USGS, 1994). Phosphorus and nitrogen levels in the Runnins River are high enough to cause eutrophic conditions in a lake. However, the shallow ponds with short hydraulic detention times, where the main stem Runnins River flows, are less susceptible to nuisance algal bloom. An algae bloom was noted in a pond in the upper reach (see photograph 1). In shallow areas with well developed flow, nutrients are more likely to foster strong growths of aquatic macrophytes than algae blooms.

Nitrate-nitrogen levels ranged from 0.02 to 1.0 mg/l, ammonia-nitrogen levels ranged from 0.31 to 1.8 mg/l, total Kjeldahl-nitrogen levels ranged from 0.35 to 3.0 mg/l. The highest instream nitrogen levels occurred at Pleasant Street and Highland Avenue, and appear to follow a similar pattern as fecal coliform. Decreases between Highland Avenue and Mink Street could be attributable to nitrogen uptake by wetland plants. Total phosphorus levels ranged from 0.13 to 0.16 mg/l at two stations on 19 June, and 0.03 to 0.09 mg/l at seven stations on 18 July.

Chloride levels ranged from 36 to 126 mg/l, which are elevated compared to the 2.0 to 13 mg/l in typical surface and groundwater samples in the United States (Snoeyink and Jenkins, 1980). The MADEP survey suggests elevated chloride levels could be associated with raw sewage, wastewater from septic systems, and road salting operations. The survey refers to a study examining effects of septic tank wastes on water quality in the Ipswich and Shawsheen River Basins in Massachusetts (Morrill and Toler, 1973). Morrill and Toler found an increase of 50 mg/l of chloride per 200 gallon per day of domestic wastewater, and a similar investigative approach, requiring water quality analyses of groundwater and tap water, could be applied to the Runnins River (MADEP, January 1992). However, at the lower instream stations, high chloride levels may be associated with some degree of saltwater intrusion.

Class B water quality standards were exceeded for pH, DO, and DO percent saturation. The pH ranged from 5.3 to 6.1, indicating an acidic condition. Dissolved oxygen levels ranged from 7.6 mg/l at Pleasant Street to 2.3 mg/l at Mink Street on 18 July. With water temperatures from 16 to 19 degrees Celsius, DO saturation ranged from 25.8 to 82 percent.

Alkalinity, a measure of the capacity of a water to neutralize acid, ranged from 33 to 75 mg/l. Alkalinity in typical surface and groundwater samples in the United States ranges from 18.3 to 339 mg/l, with the lower range typical of many New England rivers and lakes in granite basins (Snoeyink and Jenkins, 1980). Alkalinity is important for fish and other aquatic life in freshwater organisms because it buffers pH changes. Components of alkalinity, such as carbonate and bicarbonate, complex with some toxic heavy metals, sometimes reducing metals toxicity. A minimum alkalinity of 20 mg/l is recommended to protect freshwater aquatic life (USEPA, 1986).

Hardness, the sum of divalent cations, primarily calcium and magnesium, ranged from 41 to 113 mg/l as calcium carbonate. Total hardness in typical surface and groundwater samples in the United States ranges from 14.6 to 369 mg/l, with the lower range typical of many New England rivers and lakes in granite basins (Snoeyink and Jenkins, 1980). Reduction of the toxicity of metals has been observed to be related to increased hardness (USEPA, 1986).

Suspended solids ranged from less than 1 to 3 mg/l. Total solids ranged from 120 to 866 mg/l. Although there are no numerical limits, criteria for freshwater fish and other aquatic life indicate that settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life (USEPA, 1986). These levels of solids are low and unlikely to cause such problems. Turbidity ranged from 2.3 to 9.9 nephelometric turbidity units (NTU), and increased steadily from upstream to downstream. Class B standards limit the turbidity increase to 5 NTU above background when the background is less than 50 NTU. The lower reaches may naturally be more turbid.

Metals were analyzed in samples from two stations on 19 June, and five stations on 18 July. Iron was found at levels within plus or minus 50 percent of the freshwater chronic value of 1 mg/l (USEPA 1992). Both 19 June samples exceeded freshwater acute values of 0.0039 mg/l cadmium (USEPA, 1992). Copper measurements found less than detectable concentrations. However, the detection limits ranging from 0.2 to 0.3 mg/l were greater than the freshwater acute and chronic criteria of 0.018 and 0.012 mg/l (USEPA, 1992). Consequently, it is not possible to determine if copper levels exceeded criteria. Chromium, lead, nickel, and zinc concentrations were less than the freshwater acute values (USEPA, 1992). Aluminum criteria were reported in the

survey to not exceed 1986 criteria; however, it is not clear if they would have met more recent pH-dependent criteria (FR, 1988).

Samples from Mink Street and Highland Avenue were analyzed for a wide variety of organic compounds. No detectable levels of base neutral and acid extractables, and total petroleum hydrocarbons were found. The volatile organics, benzene and isopropyl ether, were at Mink Street, and methyl-tert-butyl-ether was found at both locations. An oil sheen and a yellowish hue opaque appearance were noted during visits to sample the Mink Street site (MADEP, January 1992). At Mink Street, the concentration of 6.3 mg/l benzene, a primary component of gasoline and a pollutant, exceeded the freshwater acute value 5.3 mg/l (USEPA, 1992).

(2) <u>Sediment Analyses</u>. Sediment samples were collected from the shore at 18 sites along the Runnins River in June 1992, and trace metals and organic chemicals were detected. The Runnins River appears to have sediment problems at the Grist Mill Dam in Seekonk, MA and in the vicinity of Mobil Oil Corporation's property in East Providence. The Grist Mill dam is downstream from a golf course where herbicide use on the grounds could lead to elevated levels of iron, lead, copper, arsenic, zinc, mercury, as well as organic chemicals. The samples taken near the Mobil facility also contained elevated levels of lead, copper, arsenic, zinc, nickel, and mercury. In addition, several detectable trace metals and organic compounds were found in sediment samples taken from a tributary to the Runnins River, called Orange Juice Creek by locals, downstream from the former Kent Heights landfill in East Providence.

Standards have not been established for sediments as they have for water. However, various State and Federal agencies have developed classification systems and indices for purposes such as dredged material disposal and sediment cleanup standards. Among the first were guidelines developed by EPA in 1977 for classification of degree of pollution of Great Lakes Harbor sediment. The most recent and comprehensive work was by Long and Morgan (1990). As part of a national survey, they compiled previous sediment investigations and developed three standards for evaluation of sediment constituent concentrations: ER-L, ER-M, and AET. ER-L is a concentration at the low end of the range in which effects were observed; ER-M is a concentration approximately midway in the range of reported values associated with biological effects; and AET is the sediment concentration of a selected chemical, above which statistically

significant effects always occur, and, therefore, are "always expected."

Several organic compounds were measured in sediments at two locations on Orange Juice Creek, downstream from a former municipal landfill in Kent Heights, East Providence. This landfill is south of U.S. Route 6 and east of State Route 114. Most notable were PCB levels of 0.6 and 0.85 ppm which exceed the ER-L value of 0.050 ppm and the ER-M value of 0.40 ppm.

Cadmium, nickel, and aluminum concentrations in all sediments were in the range of unpolluted waters, according to the Great Lakes Sediment Guidelines, and also below the ER-L, ER-M, and AET. Copper, lead, mercury, arsenic, and iron concentrations exceeded some of the threshold values, and are listed in table C-4.

Iron levels were high in sediments at three of the sampled sites; concentrations of 42,000 and 35,000 ppm were measured at the Grist Mill dam, and 49,000 ppm at a site adjacent to the Mobil facility. However, iron is one of the most common elements of the earth's crust, and iron, as well as aluminum and magnesium concentrations are typically high in New England soils.

Lead levels in four sediment samples exceeded 60 ppm; therefore, the sediments would be classified as heavily polluted under the Great Lake Sediment Guidelines. Two samples at the Grist Mill dam measured 190 and 165 ppm, while one of the Orange Juice Creek sites measured 70 ppm, and the site near the Mobil facility measured 95 ppm. All four levels exceed the ER-L of 35 ppm, and two exceed the ER-M of 110 ppm, but no site was greater than the AET limit of 300 ppm.

Copper levels in sediments were elevated at three sites. In sediments near the Mobil facility, copper levels measured 75 ppm, exceeding the 50 ppm threshold for heavily polluted sediments according to the Great Lake Sediment Guidelines and the ER-L of 70 ppm. Two sites at the Grist Mill dam measured 44 and 46 ppm, which puts them in the category of moderately polluted according to the Great Lake Sediment Guidelines. No copper levels were greater than the ER-M and AET levels of 390 and 300 ppm, respectively.

Arsenic levels in sediments were somewhat high but not likely a problem in two samples from the Grist Mill dam and one from the site near the Mobil facility. At Grist

TABLE C-4

FIVE MOST CONTAMINATED SEDIMENT SAMPLING SITES
ON THE RUNNINS RIVER
SAMPLED BY MADEP-DWPC-TSS
JUNE 1992

USACOE-NED, May 1994

KEY:
Great Lakes Classification Guidelines:
- NP Not Polluted
- MP Moderately Polluted
- HP Heavily Polluted

Note: Values in () are Threshold Limits
Biological Sediment Effects Thresholds:
ER-L, ER-M, AET

Massachusetts DWPC Dredging Handbook:
- Type I Cleanest, unconfined and uncontained upland sites
- Type II Can be used as daily cover at an approved landfill
- Type III Contaminated, confined or contained disposal site

	Grist Mill 1	Grist Mill 2	Kent Heights Landfill	Catamore Indust.	Mobil Oil
Copper, ppm	**44**	**46**	**14**	**12**	**75**
Great Lakes Guidelines	MP (25-50 ppm)		NP (<25 ppm)		HP (>50 ppm)
ER-L Threshold	70 ppm				
ER-M Threshold	390 ppm				
AET	300 ppm				
DWPC Class.	Type I				
Lead, ppm	**165**	**190**	**70**	**25**	**95**
Great Lakes Guidelines	HP (>60 ppm)			NP (<40 ppm)	HP (>60 ppm)
ER-L Threshold	35 ppm				
ER-M Threshold	110 ppm				
AET	300 ppm				
DWPC Class.	Type II		Type I		
Mercury, ppm	**0.30**	**0.35**	**0.01**	**0.03**	**0.35**
Great Lakes Guidelines	NP (<1 ppm)				
ER-L Threshold	0.15 ppm				
ER-M Threshold	1.3 ppm				
AET	1.0 ppm				
DWPC Class.	Type I				

TABLE C-4 (continued)

FIVE MOST CONTAMINATED SEDIMENT SAMPLING SITES
ON THE RUNNINS RIVER
SAMPLED BY MADEP-DWPC-TSS
JUNE 1992

USACOE-NED, May 1994

KEY:
Great Lakes Classification Guidelines:
NP Not Polluted
MP Moderately Polluted
HP Heavily Polluted
Note: Values in () are Threshold Limits
Biological Sediment Effects Thresholds:
ER-L, ER-M, AET

Massachusetts DWPC Dredging Handbook:
Type I Cleanest, unconfined and uncontained upland sites
Type II Can be used as daily cover at an approved landfill
Type III Contaminated, confined or contained disposal site

	Grist Mill 1	Grist Mill 2	Kent Heights Landfill	Catamore Indust.	Mobil Oil
Arsenic, ppm	**19**	**9.5**	**2.1**	**5.5**	**14**
Great Lakes Guidelines	HP (>8 ppm)		NP (<3 ppm)	MP (3-8 ppm)	HP (>8 ppm)
ER-L Threshold			33 ppm		
ER-M Threshold			85 ppm		
AET			50 ppm		
DWPC Class.	Type II		Type I		Type II
Zinc, ppm	**435**	**365**	**48**	**205**	**535**
Great Lakes Guidelines	HP (>200 ppm)		NP (<90 ppm)	HP (>200 ppm)	
ER-L Threshold			120 ppm		
ER-M Threshold			270 ppm		
AET			260 ppm		
DWPC Class.	Type III	Type II	Type I	Type II	Type III
Iron, ppm	**42000**	**35000**	**18000**	**13000**	**49000**
Great Lakes Guidelines	HP (>25000 ppm		MP (17000-25000)	NP (<17000)	HP (>25000)
ER-L Threshold			N/A		
ER-M Threshold			N/A		
AET			N/A		
DWPC Class.			N/A		

Mill dam, the levels measured 19 and 9.5 ppm, exceeding the Great Lake Sediment Guidelines limit of 8.0 ppm for heavily polluted sediments. Near the Mobil facility, the arsenic level was 14 ppm, also exceeding the Great Lake Sediment Guidelines limit, classified as heavily polluted. However, none of these levels exceeded the ER-L, ER-M, or AET levels of 33, 85, and 50 ppm, respectively.

Zinc levels of 435 and 365 ppm at two locations at Grist Mill dam fell into the category of heavily polluted sediments, according to the Great Lake Sediment Guidelines of 200 ppm; and exceeded the ER-L of 120 ppm, the ER-M of 270 ppm, and the AET of 260 ppm. The site near the Mobil Oil facility, with zinc levels at 535 ppm, also exceeded all four standards. Zinc levels in sediments from Catamore Industrial Park site on Orange Juice Creek were 205 ppm, which exceeds the ER-L of 120 ppm, and is slightly above the Great Lake Sediment Guidelines for heavily polluted, but less than the ER-M and AET.

Mercury levels were slightly high in the Grist Mill dam sediment samples, which measured 0.30 and 0.35 ppm, and near the Mobil facility, which measured 0.25 and 0.35 ppm. According to the Great Lake Sediment Guidelines, all the levels classify as nonpolluted waters, but exceed the ER-L of 0.15 ppm. These levels are also below the ER-M and AET limits of 1.3 and 1.0 ppm, respectively.

h. NEIWPCC - Runnins River Initiative, 1992. The New England Interstate Water Pollution Control Commission (NEIWPCC) sponsored a plan to sample instream stations during both dry and wet weather, and stormwater management systems and unmitigated urban runoff from roads and parking lots during wet weather. Goal of the Runnins River Watershed Initiative was to assess and understand effects of stormwater runoff on the Runnins River and to identify areas of special concern. The plan for dry weather sampling included only instream locations at Taunton Avenue (U.S. Route 44), the Firefly Country Club golf course (between Taunton and Fall River Avenues), and Wampanoag Trail (State Route 114, in the vicinity of the Mobil Oil Corporation's East Providence Terminal); and outfalls at Mink Street and in the Orange Juice Creek tributary. Because stormwater management outlets are not expected to release flow during dry weather, Catamore Industrial Park swale and Home Depot sites were not proposed for this phase. To date, volunteers have collected only dry weather samples, which were received by Alpha Analytical Laboratories, 1 September 1992.

Sampling occurred during conditions not totally typical of dry weather conditions. According to NOAA climatological data collected at the Providence Airport Weather Service Observatory, total rainfall of 6.06 inches in August 1992 was 2.02 inches above normal; 2.73 inches fell on 9 August, and 1.11 inches on 18 August. Although no significant rainfall occurred within two weeks prior to the sampling event, subsurface and groundwater flows to the river, due to rainfall in the first one-half of the month, may make the data more representative of high groundwater table and subsurface flow conditions than antecedent dry weather conditions.

Dry weather suspended solids, nutrients, hydrocarbons, and fecal coliform are displayed in table C-5. It shows water quality conditions more typical of those expected during wet weather than dry. Fecal coliform are high, with all samples exceeding class B standards, and nutrient levels are also elevated. Total suspended solids are low; however, there is an anomaly in that volatile solids exceed total suspended solids. It is not clear what the dissolved solids are, especially since hydrocarbons are nondetectable; otherwise, the data show few discernible patterns. Generally, upstream and downstream concentrations are about the same. Exceptions are at the golf course and near the Mobil facility, where levels of nitrate/nitrate and kjeldahl nitrogen, and fecal coliform levels are less downstream than upstream. Inferences as to the cause, beyond sampling variation, are not warranted since neither the distance between upstream and downstream sample locations, nor the time of travel between them, are indicated.

i. <u>Pokanoket Watershed Alliance</u>. On a monthly basis, volunteer members of the Pokanoket Watershed Alliance (PWA) sample thirteen stations on the Runnins River and three in Hundred Acre Cove. The PWA also samples fecal coliform levels at various other stations in tributary streams and stormwater conveyances. The PWA usually tabulates water quality and fecal coliform data in 6-month intervals with graphs of data values versus time at each station. Data reviewed here represent twelve months of sampling for water temperature, pH, DO, salinity, and fecal coliform bacteria, from June 1992 to May 1993, with the exception of fecal coliform data, which continued through December 1993. The PWA periodically sends split samples to a certified laboratory to verify its fecal coliform counts.

To simplify interpretation of PWA results, the river was divided into four reaches, with four sampling sites in the

TABLE C-5

POKANOKET WATERSHED ALLIANCE

RUNNINS RIVER

DRY WEATHER SAMPLE - AUGUST 31, 1992

PARAMETER	WR1A Taunton Upstream	WR1B Taunton Downstream	WR2A Golfcourse Upstream	WR2B Gristmill Downstream	WR4A School Street	WR4B South Of Dam	WR5 Mink St. 30" Pipe	WR3 Orange Juice Cr.	RDL
CHEMICAL ANALYSIS									
Solids, Total Suspended	ND	5.3	ND	ND	ND	21	ND	11	5
Solids, Total Volatile	*	*	60	ND	*	*	120	90	50
Nitrogen, Ammonia	0.21	0.16	0.14	0.15	0.06	0.08	0.34	0.1	0.05
Nitrogen, Nitrate/Nitrite	1.5	1.4	1.5	0.6	0.6	0.3	1	1.1	0.1
Nitrogen, Total Kjeldahl	0.57	0.66	0.63	0.14	0.34	0.25	0.52	0.27	0.05
Phosphorus, Total	0.05	0.06	0.03	0.06	0.03	0.09	0.07	0.02	0.01
Hydrocarbons, Total	ND	ND	*	*	ND	ND	ND	ND	0.5

Chemical Analysis by Alpha Laboratories, Inc. Westborough, MA

FECAL COLIFORM ANALYSIS /100 mL	WR1A	WR1B	WR2A	WR2B	WR4A	WR4B	WR5	WR3
Bio Analytical Lab	690	690	460	250	4700	1100	950	*
RCR Redigel Method	560	600	420	240	3080	1560	760	40
Millipore Sampler Method	720	1420	500	400	4640	1800	840	60

Coliform Analysis by Bio Analytical Lab, Inc. North Kingstown, RI
Analysis Using Redigel and Millipore Method by Pokanoket Volunteers

* Sample Not Taken This Station

upper reach of the Runnins River, three in the middle, five in the lower, and three in the Barrington River. The three freshwater reaches of the Runnins River have a class B water quality classification, while the Barrington River has a class SA (see plate 11 for location of sampling stations, breakup of river reaches, and subbasin drainage areas, as determined in Hydrologic Appendix B).

Results, summarized in table C-6, show that fecal coliform contamination is a problem in the Runnins River and Hundred Acre Cove. In the Runnins River, 55 percent of all monthly samples exceed the class B standard. In the cove, 75 percent of samples exceed the class SA standard for shellfish harvesting, which is much stricter than the class B standard for swimming in the river.

The middle and lower reaches of the Runnins River are more contaminated with fecal coliform than the cove, as 95 percent of samples in these reaches exceed 14 per 100 ml, compared to 75 percent of samples in the cove. Similarly, 75 percent of middle and lower reach Runnins River samples, but only 30 percent of cove samples, exceed 200 per 100 ml. Table C-6 also shows the geometric mean of all monthly samples at each station. The average value for middle and lower reach stations is 400 per 100 ml, while average for stations in the cove is 70 per 100 ml.

In contrast to fecal coliform, more upper than middle and lower reach samples fell below the class B minimum DO level of 5 mg/l. Fifty percent of samples in the upper reach failed to meet the standard, and levels below 1.5 mg/l occurred three times at Prospect Street. Between Arcade Avenue and the "30-inch culvert" station, only 10 percent of samples fell below the class B standard. However, at School Street, 30 percent of DO samples failed to meet the standard. Low DO levels typically occurred in the summer months. The DO data record in the cove is incomplete, as no water quality samples were taken from September 1992 to April 1993. In the remaining months, samples met the class SA level of 6 mg/l.

Although slightly acidic, pH levels generally were within the desirable range for class B or SA waters, as applicable. Temperatures in the Runnins River were generally within the desirable range for warm water fish habitat. Salinity levels ranged from 0.2 to 1.2 parts per thousand (ppt) at Mink Street, and 9.4 to 30.6 ppt in Hundred Acre Cove.

TABLE C-6

SUMMARY OF RESULTS OF RUNNINS RIVER
FECAL COLIFORM MONITORING
BY THE POKANOKET WATERSHED ALLIANCE
JUNE 1992 - DECEMBER 1993

As analyzed by USACOE-NED, May 1994

Station Name/	Number of Monthly Samples	Percent of Station Samples Exceeding Standard SA (% > 15)	Percent of Station Samples Exceeding Standard B (% > 200)	Fecal Coliform, per 100 ml Peak	Fecal Coliform, per 100 ml Geometric Mean
RUNNINS RIVER - UPPER REACH (Class B)					
Walnut St.	16	50	6	5,400	9
Prospect St.	14	80	30	1,320	40
Woodward St.	16	75	25	3,050	56
Greenwood St.	15	25	20	840	32
RUNNINS RIVER - MIDDLE REACH (Class B)					
Arcade Ave.	19	100	75	3,140	370
T-4, Mouth	18	90	70	11,400	530
Taunton Ave.	19	90	75	4,460	320
Fall River Ave.	19	100	80	2,180	370
RUNNINS RIVER - LOWER REACH (Class B)					
County St.	17	100	70	2,700	440
Highland Ave.	19	100	85	2,120	430
Mink St.	19	100	85	5,700	460
30" Culvert	18	80	40	3,140	70
School St.	18	100	85	5,450	660
BARRINGTON RIVER- HUNDRED ACRE COVE (Class SA)					
WPRO Tower	13	90	55	2,100	160
Cove - West	16	75	20	2,150	40
Cove - East	14	55	15	1,400	12

Channel physiography has not been described in detail. Mean channel width was not measured, but appears to range from 5 to 15 feet. Channel slope is approximately 0.003 ft/ft in the upper and lower reaches, and 0.006 in the middle reach. Average water depth at time of sampling varied from only 0.3 foot in the upper to 0.8 foot in the lower Runnins River. Minimum water depth of zero feet was recorded at Prospect Street in the upper reach. Maximum water depth of 1.3 feet was recorded at Fall River Avenue and County Road. In the Barrington River, tidal water depth ranged from 0.1 to 2.1 feet at sampling times.

(1) Upper Reach. The first reach comprises the Walnut (photograph 1), Prospect (photograph 2), Woodward, and Greenwood Street midstream water quality sampling stations. Contributing drainage subbasins are located entirely within Seekonk and Rehoboth. Total drainage area at the lowest station is 2.72-square miles at Greenwood Street.

In the 19-month fecal coliform sampling period, 20 percent of samples exceeded the class B standard of 200 per 100 ml. Percent exceedance at individual stations ranged from 6 percent at Walnut Street to 32 percent at Prospect Street. This reach does not include any tributary stream or stormwater drainage pipe sampling sites.

Overall fecal coliform levels improved in this reach in 1993 relative to the last six months of 1992, with 9 to 3 samples exceeding the standard. However, on 11 September 1993, counts at Walnut and Woodward Streets peaked at 5,400 and 3,050 per 100 ml, respectively. On this date, samples in the middle and lower reaches ranged from 100 per 100 ml at County Avenue to 3,400 per 100 ml at Mink Street; but there was no flow at several intermediate sampling stations.

DO content for the four sites in this reach was fairly constant throughout each season of the year; rising to approximately 8 to 10 mg/l in the winter, and falling to approximately 3 mg/l in the summer. The class B standard requires a minimum DO level of 5 mg/l. From May to November, DO levels below the standard pose a threat to fish and plant life. During the 13-month monitoring period, 21 of 42 samples fell below the class B minimum DO level. An average depth of only 0.3 foot was recorded in this reach, and several stations were dry at various times in the summer and fall of 1993.

The pH level at the three uppermost stations measured between 5.0 and 6.0, outside the class B range of

pH 6.5 to 8.3. The most extreme pH range from 5.3 to 8.7 was at Greenwood Street, the last station in this reach. The variability in pH and slightly acidic results may be due to acidic precipitation or releases of organic acids from wetlands.

Water temperature monitoring in the Runnins River began in August 1992 and continued to May 1993. Water temperatures for each of the four stations are consistent. Temperatures peaked at approximately 20 degrees Celsius in September 1992, and declined to -2 degrees Celsius in January 1993. Since these values are consistent, and thermal discharge does not seem to be an issue in this part of the river, there does not seem to be a problem with the temperature of the river.

(2) Middle Reach. Total drainage area is 5.85-square miles at Fall River Avenue, the lowest station in this reach. Subbasins draining to this reach are located entirely in Seekonk, MA (Hydrology Appendix B). Midstream sampling stations are located at Arcade Avenue (photograph 3), Valley Street tributary mouth (T-4), Taunton Avenue (photograph 4), and Fall River Avenue. Additional fecal coliform samples were taken at Pleasant Street (photograph 5) and Brookhill Avenue, on Catherine Tributary (T-5), and stormwater drainage pipe outfalls, near Brookhill Avenue in Seekonk, MA. High fecal coliform levels appear to be a problem in this reach, where 70 percent of samples from midstream stations and approximately 35 percent of samples from other stations exceed the class B fecal coliform standard.

At Arcade Avenue, 75 percent of 19 monthly fecal coliform samples exceeded 200 per 100 ml. At the mouth of the Valley Street tributary (T-4), which drains a portion of northwestern Seekonk, 70 percent of a total of 18 monthly samples exceeded the standard, and more than 50 percent exceeded 1,000 per 100 ml. The highest level at T-4 was 11,400 per 100 ml, on 15 August, 1992. This station had the highest levels of all stations in 8 of 19 monthly samples. At Taunton Avenue, 75 percent exceeded the standard. At Fall River Avenue, 80 percent of 18 monthly samples exceeded the standard. The geometric mean ranged from 320 at Fall River Avenue to 530 at T-4.

Catherine Tributary (T-5) enters the Runnins River from the east, between Pleasant Street and Old Grist Mill Pond (photograph 6). Upstream of T-5's confluence with the Runnins River, 20 percent of samples exceeded the standard.

Samples from the Brookhill West pipe exceeded the standard twice in six monitored months, with 7,620 per 100 ml on 10 July and 900 per 100 ml on 11 September 1993. Samples from the Brookhill East pipe met the standard in all six monitored months. Results varied from less than 1 to 40 per 100 ml.

In the middle reach, DO levels remained above the class B minimum of 5 mg/l for 36 of 40 monitored months. At Fall River Avenue, DO did not fall below 7 mg/l in all 13 months that this station was monitored.

The pH levels in middle reach of the river fell slightly below the class B range of pH 6.5 to 8.3. Each site in this section recorded values between pH 6.0 and 8.0. As in the upper reach, slightly acidic results are probably due to acidic precipitation or release of organic acids from wetlands.

Water temperatures in this reach are similar to temperatures recorded in the upper reach, except that cooling occurred sooner. This change is very slight and does not appear to be caused by thermal releases.

(3) Lower Reach. Total drainage area is 9.04-square miles at Mink Street, the lowest station in this reach. Subbasins draining this reach are located in both Seekonk, MA, and East Providence, R (Hydrology Appendix B). Two major interchanges of Interstate Route 195, with State Routes 114A and 114, are located in this reach. Midstream stations are at County Street, Highland Avenue (U.S. Route 6, photograph 7), Mink Street, a 30-inch diameter culvert, and School Street (photographs 8 and 9). Seventy-five percent of midstream fecal coliform samples exceed 200 per 100 ml. On two occasions, the class B standard was exceeded by a factor of 25.

Seventy percent of 17 monthly fecal coliform samples at County Street exceeded 200 per 100 ml, and 25 percent exceeded 1,000 per 100 ml. Eighty-five percent of 19 samples at Highland Avenue exceeded 200 per 100 ml, and approximately 10 percent exceeded 1,000 per 100 ml. Eighty-five percent of 18 samples at Mink Street, exceeded 200 per 100 ml, and approximately 15 percent exceeded 1,000 per 100 ml. Mink Street has the third highest geometric mean of all stations, after School Street and the mouth of T-4. At the "30-inch culvert", only 40 percent of 18 monthly samples exceeded the standard. This pipe was dry on 14 August 1993, and this sample location may not be

representative of midstream conditions. Eighty-five percent of 18 samples at School Street exceeded 200 per 100 ml, and approximately 40 percent exceeded 1,000 per 100 ml. The geometric mean of all School Street samples was 660 per 100 ml, the highest of all stations.

The PWA conducted additional fecal coliform sampling at School Street on average of eight times per month from 1990 to 1992. In the last six months of 1992, the highest count was 107,000 per 100 ml on two occasions. Forty-seven percent of 114 samples at School Street exceeded 1,000 per 100 ml, and 13 percent exceeded 10,000 per 100 ml during this period. From this additional data, it appears that wet weather fecal coliform levels at School Street are usually 10 to 100 times greater than dry weather levels.

Midstream fecal coliform data were supplemented by samples from tributary streams and stormwater conveyances. Levels ranged from 80 to 520 per 100 ml and exceeded the standard three times in five monitored months, in a shallow stream at Warren Avenue in East Providence, between Interstate 195 and County Road. Levels of 1,600, 3,120, and 700 per 100 ml were recorded in April, July, and August 1993 in Orange Juice Creek, another tributary in East Providence. Orange Juice Creek drains the west side of Kent Heights and enters the Runnins River one-quarter mile below Highland Avenue. Three of eight monthly samples in Orange Juice Creek exceeded the class B standard.

Three stormwater detention basins that drain commercial properties on Highland Avenue in Seekonk were only sampled on December 1993 and met the standard. However, a small stream and pipe from one property exceeded the standard 3 of 5 and 3 of 6 times, respectively.

The DO content in this reach steadily rose from June to February, except September when DO at all midstream water quality stations fell below the class B standard. Low levels of 3.1 mg/l at School Street in July, and 3.9 mg/l at Mink Street in September, indicate high organic loading, and pose a threat to fish and plant life. At School Street, 31 percent of samples did not meet the DO standard. At County and Mink Streets, out of 13 samples at each site, 1 and 2, respectively, did not meet the DO standard. The 30-inch culvert and Highland Avenue stations were not sampled for DO content.

The majority of pH values ranged from 6.4 to 7.0 in this reach, barely outside the lower limit of the 6.5 to

8.3 standard range. Levels fell below the standard during December, January, February, and March. As with other river reaches, the slightly acidic water is probably due to acidic precipitation or release of organic acids from wetlands.

• Water temperatures are consistent with levels recorded in upstream reaches. The minimum recorded water temperature occurred in January and February. Temperatures increased until July and August, peaking at approximately 22 degrees Celsius. The water temperature in this reach is consistent with seasonal changes. Salinity readings were taken at Mink Street, "storm pipe", and School Street stations. Salinity levels, ranging from 0.2 to 2.8 ppt, are below the brackish threshold, considered to be 8 or 9 ppt.

(4) Hundred Acre Cove. Downstream from the Mobil dam, the Runnins becomes the Barrington River tidal flats (photograph 10). Total drainage area is 13.75-square miles at the lower end of this reach, at Massasoit Avenue bridge in Hundred Acre Cove. Contributing drainage subbasins are located in Barrington and Seekonk. Three midstream water quality sampling stations, accessible only by boat, are located near the WPRO radio tower, in the main channel, just west of the constriction known as "The Tongue," and on the east side below "The Tongue." In December 1992, a major Nor'easter was in progress, and portions of the cove were iced over in January and February 1993.

In this reach, 75 percent of midstream and approximately 70 percent of all samples exceed the 14 per 100 ml class SA fecal coliform standard. Of 13 samples at the WPRO Tower, 90 percent exceeded the class SA standard, and 55 percent exceeded 200 per 100 ml. Peak levels of 2,100 and 2,500 per 100 ml in the main channel stations, and 1,400 per 100 ml on the east side, were recorded on 11 September 1993. As fecal coliform are tracked downstream in the cove, percent exceedance of the class SA standard decreases from 90 at WPRO tower, to 75 at the west side, and 55 at the east side. Similarly, the geometric mean and percent exceeding 200 per 100 ml also decrease.

Fecal coliform levels at supplemental stations near Monarch and George Streets exceeded the class SA standard 3 of 10 and 6 of 10 monitored months, respectively. Levels at Monarch Street exceeded 90,000 per 100 ml for 3 of 10 monitored months, in January, February, and March 1993, but were below 1 per 100 ml the other seven times. The Monarch Street sampling point is a stormwater conveyance, northwest of Nockum Hill in South Seekonk, MA. The highest level at George Street was 1,900 per 100 ml in September

1993. The George Street sampling point is a small tributary stream, east of Nockum Hill in Barrington, RI.

From July through September, DO levels at all cove stations fell below the 6 mg/l minimum class SA standard. Levels ranged from 5.0 to 11.4 mg/l. The pH levels ranged from 6.5 to 8.0, slightly below the class SA range of 6.8 to 8.5. Temperatures in the cove vary less than in the Runnins River reaches, primarily due to mixing of freshwater with ocean water. The summer high was 25.5 degrees Celsius, while the winter low was 5.5 degrees Celsius. Salinity ranged from 9.4 to 29.6 ppt in the cove. This compares to salinity levels of 33 to 35 ppt in normal ocean water.

(5) Discussion. Upon comparison of data sets from various sampling events, few discernible patterns emerged, either because slugs of contamination were picked up at some but not all stations, or there is a natural absence of patterns. Fecal coliform levels did not correlate well with the amount of prior rainfall, departure of monthly rainfall from normal total, or flow rate. Fecal coliform concentrations, as tracked downstream on any given sampling date, often increased and decreased randomly, from one station to another, by factors up to 100. It appears that grab samples are too simplistic for detecting slugs of contamination, especially when not timed to take into account stream time travel between stations.

An exception to apparent randomness of fecal coliform levels is the data set from 12 December 1992 when consistently elevated levels followed 2.4 inches of rainfall the previous day, as recorded at Providence Airport Weather Station Observatory. Due to storm conditions on this day, the cove was not sampled. All Runnins River samples except Prospect Street exceeded the class B standard. The geometric mean fecal coliform level was 1,700 per 100 ml, the highest of all the sampling dates. Also, the range of factors (0.1 to 4), where levels at individual stations deviated from the geometric mean, was narrow compared to other sampling dates. During December, departure from normal monthly precipitation was 2.36 inches. Local records of the 12 December 1992 Nor'easter may indicate depth of frozen ground and height of snowbanks, both of which could have affected runoff conditions. In general, review of stream flow rate, antecedent precipitation, soil moisture conditions, and special occurrences, such as pump station overflows or other raw sewage discharges, for as many sampling dates as possible, may suggest ways of categorizing high and low runoff scenarios, and evaluating the propensity

for potentially contaminated groundwater to discharge to the river.

Since some contamination sources were identified and abated during the monitoring period, comparison of early with later fecal coliform data sets may be misleading. In March 1992, a sewage pumping station overflow was abated in East Providence. In April 1992, a problem toilet was located at a school in Barrington, and a residence was connected to the municipal sewer in August 1992. In January 1992, the Seekonk Board of Health ordered repair of a septic system at a truck repair facility. In April 1993, a pipe plug was inserted into a stormwater conveyance at Monarch Street, in South Seekonk. In April 1993, a line blockage was removed at a private wastewater treatment plant in Seekonk, MA.

In order to assess whether the Runnins River is the major contributor of fecal coliform to the cove, the river and cove need to be considered as a coupled system. The volume and concentration dilution factors in the cove relative to the Runnins River need to be quantitatively assessed. Fecal coliform concentration decreases by factors of 4 at WPRO tower, 17 at Cove-West, and 55 at Cove-East, based on the School Street geometric mean values of 660 per 100 ml. However, the flow rate in the cove at any given time is not known since it varies in the course of each tidal cycle. Based on an estimated average tidal flux of 4,100 cfs and the mean monthly river flow rate (see plate 4, Appendix B), the volume dilution ratio could exceed 200 at extreme floodtide flows.

Not only must flow and concentration be known in both the river and cove, but variation of concentration over time at each station must be tracked over several tidal cycles so that ephemeral phenomena can be followed downstream. Thorough analysis of this problem would probably entail unsteady flow modelling of the estuary. This would require extensive data collection efforts, possibly involving tracer studies of Runnins River streamflow, to quantify how its pollutant load is distributed in the cove independently of other inputs. Sampling would need to be conducted over selected river and tidal hydrographs, with time of sampling at stations correlated to stream time travel. Since flow rates would need to be gaged or estimated, tributary and stormwater conveyance flow would also need consideration in developing stage-discharge relationships.

In the subbasins and reaches they monitored, PWA volunteers gained considerable detailed knowledge, including

septic system performance histories, dye test results, and ponds that are particularly attractive to waterfowl. The PWA recently prepared proposals to monitor groundwater fecal coliform levels in the lower reach of the Runnins River, with the purpose of identifying potential contamination sources and modes of transport. Other community and educational groups are also active in studying Runnins River watershed ecology.

j. Palmer River Watershed, Town of Seekonk, Massachusetts, 1993. The town of Seekonk recently conducted surface water sampling in two Palmer River tributaries, in a residential and agricultural area immediately east of the Runnins River watershed. The area is bounded by County Road to the north and Interstate Route 195 to the south. The study design was approved by the MADEP's Bureau of Municipal Facilities as one component of the ongoing assessment of the town's wastewater needs. Purpose and results are described in a Letter Report on Wastewater Needs in Area 5, prepared by Fay Spofford and Thorndike, Inc., Engineers, and dated 12 August 1993.

Three rounds of surface water samples from seven locations on two Palmer River tributaries were analyzed for alkalinity, ammonia-nitrogen, total kjeldahl nitrogen, nitrate-nitrogen, BOD_5, chloride, phosphorus, total coliform, fecal coliform, and fecal streptococci. Sampling rounds were planned to occur during low groundwater and dry weather conditions--high groundwater and dry weather, and high groundwater and wet weather. Results show contaminated surface water at all sampling locations. Surface water contamination was attributed to agricultural practices at one location, and to a combination of septic system effluent, lawn fertilizer, and street runoff at six locations.

The report concluded that septic system effluent contributed to contamination of some surface waters examined during the sampling program. This conclusion was based on findings and knowledge of recurring problems with septic system operation in area 5. Furthermore, the report stated that presence of contamination warrants improvement of wastewater treatment and disposal in this area.

k. Groundwater Monitoring. Both Rhode Island and Massachusetts documented adverse water quality impacts on municipal and private drinking water supply wells in densely populated areas, relying on septic systems. According to RIDEM, nonpoint source pollution from salt storage sites, landfills and dumps, leaking underground storage tanks, underground injection control sites, and surface

impoundments located in East Providence has adversely impacted the suitability of local stratified drift deposits as a source of drinking water (R 305b, 1992). However, because there are no municipal wells or designated sole-source aquifers in the study area, and routine monitoring of private drinking water wells is not required, few ground-water investigations of drinking water quality have been conducted in the study area.

East Providence is serviced with public water from the Scituate Reservoir in Scituate, R. Nevertheless, the area's stratified drift sediments are significant as reservoirs of drinking water (Town of Seekonk, 1981). Over 90 percent of Seekonk residences, and a majority of businesses, obtain their water from the Seekonk Water District's wells in a glacial outwash aquifer, near Central Pond and Coles Brook on the Ten Mile River system, immediately northwest of the Runnins River surface watershed
(Town of Seekonk, 1981). Private water supply wells serve an estimated 60 people in East Providence and 470 people in Seekonk (RIDEM Division of Air and Hazardous Materials, 1991). Since private drinking water wells are not required to be monitored, the only ground water quality investigation in the area of interest are for miscellaneous reasons at various locations, such as hazardous waste sites.

In conjunction with proposed installation of individual sewage disposal system leaching fields, Seekonk Conservation Commission required the Price Club to perform predevelopment ground and surface water quality monitoring. The Price Club property, formerly a Drive-In Theater, is bounded to the west by the left bank of the Runnins River, a drainage ditch and pipeline corridor to the south, and to the north and east by Highland Avenue (U.S. Route 6). The sampling was required by Seekonk Conservation Commission Order of Conditions, dated 1 May 1992. Results are described in a Final Report of Baseline Water Quality Monitoring dated 21 April 1993, prepared by the developer's engineering consultant, The Environmental Scientific Corporation, a Division of Keyes Associates.

The Price Club's baseline monitoring program utilized six groundwater monitoring wells and two surface water stations. Wells were sampled monthly from June to October 1991. The class B surface water standard for fecal coliform was exceeded by 6 of 12 upgradient and 2 of 13 downgradient samples. Levels of 2,000 per 100 ml were exceeded by 5 upgradient and 2 downgradient samples. Lowest levels reported were less than 10 per 100 ml. The report indicates high fecal coliform levels in the more upgradient wells may

be associated with discharges from nearby individual sewage disposal systems. The report suggests that sandy soils in the area may not effectively remove fecal coliform, especially during periods of high groundwater flow.

Ongoing hazardous waste site investigations at the Mobil Oil Corporation's East Providence Terminal are being overseen by RIDEM's Division of Site Remediation. Preliminary results indicate gasoline contaminated groundwater infiltrates a RIDOT storm drain in the State Route 114 median strip, immediately upstream of Mink Street. Extensive groundwater sampling is planned to define pollutant plumes from various industrial activities on the 1-square mile complex, where there are more than 40 oil storage tanks.

Investigations at a former municipal landfill at Kent Heights in East Providence found lead and mercury in samples from two overburden wells in 1983. Other hazardous waste site investigations were conducted in Seekonk. Many of these involved leakage from underground tanks of gasoline, diesel fuel, or heating oil (MADEP-DWPC-TSS, 1992).

Fecal coliform and chloride concentrations in excess of groundwater quality standards were found in Seekonk monitoring wells in the course of preliminary investigations under a wastewater facility planning grant in the late 1970s and early 1980s (Town of Seekonk, 1981). In addition to information on the region's geology, the preliminary Draft Wastewater Facility Plan presents specific subsurface investigation results, soil conditions, depth below ground surface of the groundwater table, and its seasonal fluctuations.

5. POLLUTION SOURCES

a. General. Water quality in the Runnins River is primarily degraded by nonpoint sources. There are no permitted point source discharges in the watershed, such as municipal or industrial wastewater treatment plants. However, stormwater discharge permits have been issued to two East Providence industries. Additionally, major point source discharges of wastewater, including combined sewer overflows into Narragansett Bay, could have adverse effects on water quality in the Warren and Barrington Rivers, including Hundred Acre Cove.

Nonpoint pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away pollutants resulting from natural

and human activities, depositing them in lakes, rivers, wetlands, coastal water, and groundwaters. Runoff from nonpoint sources can be collected and concentrated via storm drains, where outlets, if large enough, may act as point sources. Therefore, although there are no permitted point source discharges at this time, there may be in the future, if and when some large existing storm drains are classified as point sources.

Based on a review of existing water quality data, fecal coliform is a major concern in the Runnins River and Hundred Acre Cove. The source of fecal coliform is feces from warm-blooded animals, which could end up in the Runnins River from a variety of sources by a number of pathways. Direct discharges may result from cross connections of sanitary lines to storm drains, sewage pump station overflows, leakage from sewer pipes, seepage from individual disposal systems, and runoff carrying feces deposited by waterfowl, farm, and domestic animals. Groundwater recharged by flows, contaminated with fecal coliform from any of these sources can also convey fecal coliform to the river, especially through gravel or any other connection to the river with poor filtering properties. There have been no major documented cases of illicit and improper connections of sanitary sewers to storm drains in this area.

Due to its urban character and minimum investment to date in best management practices, East Providence probably generates significant quantities of stormwater and associated pollutants. The existing data are inconclusive for determining specific sources of fecal coliform contamination or for apportioning this contamination to either East Providence or Seekonk. However, based on the identification of potential sources of fecal coliform in East Providence, it would appear that East Providence is probably not a significant contributor of fecal coliform. Possible sources are identified in chapter "VIII. CONCLUSIONS", of the main report. Quantification of adverse effects on receiving stream water quality is difficult, except through estimates based on land use characteristics. However, apportioning contributions to individual communities is even more difficult because of varying approaches to management of wastewater needs. While most of East Providence and Barrington are sewered, Seekonk's residential clusters rely on cesspools, aging onsite disposal systems, and commercial establishments rely on large onsite disposal systems (see paragraph 7b).

b. <u>Point--Nonpoint Pollution</u>

(1) General. Because point and nonpoint source discharges are regulated in different ways, a review of the basis for classification is important in planning their control. Point sources are distinguished from nonpoint sources in that, historically, only point sources were regulated, although both can have equally adverse effects on receiving stream water quality. One reason nonpoint sources were not regulated in the past was that, in general, non-point sources are more diffuse and difficult to quantify than point sources.

(2) Historical Classification. The distinction between nonpoint and point sources is sometimes unclear. For example, runoff originating as a nonpoint source may ultimately be channelized to become a point source. Historically, overlaps, ambiguity, and gaps have existed in programs designed to control urban nonpoint sources programs designed to control urban point sources. Technically, the term "nonpoint source" is defined by EPA to mean any source of water pollution that does not meet the legal definition of "point source" in Section 502(14) of the Clean Water Act (CWA). That definition states:

> The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharge and return flows from irrigated agriculture.

Congress amended the CWA in 1987 to focus greater national efforts on nonpoint sources. It enacted Section 319 to control nonpoint sources of water pollution and Section 402(p) to control stormwater. Section 319 authorized EPA to issue grants to States to assist in implementing management programs or portions approved by EPA. States address nonpoint source pollution by assessing problems caused within the State, adopting management programs to control nonpoint source pollution, and implementing management problems.

Under phase I of Section 402(p) of the CWA, National Pollutant Discharge Elimination System (NPDES) permits are required to be issued for municipal separate storm sewers serving large or medium sized populations (greater than

250,000 or 100,000 people, respectively) and for stormwater discharges associated with industrial and construction activities. Permits are also to be issued, on a case by case basis, if EPA or a State determines that a stormwater discharge contributes to a violation of a water quality standard, or is a significant contributor to pollution loads to waters of the United States. EPA published a rule implementing phase I on 16 November 1990. At present, EPA has not yet promulgated regulations that would designate additional stormwater discharges, beyond those regulated in phase I.

Congressional enactment, of Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990, requires EPA and NOAA to promulgate and States to provide implementation of management measures to control nonpoint source pollution in coastal waters. The purpose of the program "shall be to develop and implement measures for nonpoint source pollution to restore and protect coastal waters, working in close conjunction with other State and local authorities."

Stormwater runoff that may be ultimately covered by phase II of the 402(p) Stormwater Permit Program is intended to be subject to the Coastal Nonpoint Source Pollution Control Program. Runoff from wholesale, retail, service, or commercial activities, including gas stations, and construction activities on sites less than five acres, not covered by phase I of the NPDES stormwater program, would be subject instead to a State's Coastal Nonpoint Pollution Control Program, once established. States have the option to implement management measures in conformity with this guidance through their 6217 management area, as long as NPDES stormwater requirements continue to be met by phase I sources in that area. States are encouraged to develop consistent approaches to addressing urban runoff throughout their 6217 management areas.

EPA also administers the National Estuary Program under Section 320 of the Clean Water Act. This program focuses on point and nonpoint pollution in geographically targeted, high priority estuarine waters. In this program, EPA assists State, regional, and local governments in developing comprehensive conservation and management plans that recommend priority corrective actions to restore estuarine water quality, fish populations,and other designated uses of the waters. In 1989, Narragansett Bay was selected as a participant in the National Estuary program.

On 3 January 1992, the Narragansett Bay Project, a partnership formed by representatives from Federal, State, and local agencies, businesses, citizens' groups, and universities, submitted the draft Narragansett Bay Comprehensive Conservation and Management Plan (CCMP) to EPA in Massachusetts, and Rhode Island, and the general public for review and comment. Among key actions outlined in the plan are updating State regulations for siting, design, construction, and maintenance of onsite sewage disposal systems; and guidance for municipal officials on the control on nonpoint source pollution, environmentally protective land, growth management practices, and development of stormwater management plans.

(3) <u>Point Sources</u>. To date, RIDEM issued two permits for stormwater discharges associated with industrial activities in the East Providence portion of the Runnins River watershed, under phase I of the Section 402(p) program. There are no permitted municipal or industrial dischargers of treated sewage or industrial wastewaters on the Runnins River. However, there are one or more small private wastewater treatment plant sites in Seekonk that have groundwater injection permits, or will require them in the future, depending on flow rate. In the larger Barrington/Warren River watershed, water quality may be adversely influenced by permitting discharges of treated sewage from municipal facilities on Narragansett Bay.

Shoreline Surveys identified about seven storm drains discharging to the Runnins River from East Providence, 11 from Seekonk, and 30 discharging into the Hundred Acre Cove area from South Seekonk and Barrington. According to the surveys, these point sources consist mostly of storm drains, drainage swales, and small streams, which include small pipes and hoses from roof drains, and sump pump discharges.

East Providence, with separate storm drainage and sewer systems and a current population just over 50,000, will probably be subject to phase II of the stormwater permit program, once implemented. All communities of the Runnins and Barrington River watersheds may eventually be subject to requirements of State Coastal Nonpoint Source Pollution Control Programs, which could include permitting, monitoring, and management of storm drains and septic systems. Therefore, the larger problem of determining the role of urban stormwater runoff to receiving water quality problems may lead to investigation of illicit or inappropriate connections to storm drainage systems along the Runnins River and Hundred Acre Cove.

Below Hundred Acre Cove, the class SC segment of the Barrington River receives permitted discharges from the town of Warren's municipal wastewater treatment facility and a seafood processing plant. The impact of these wastes on the river, in terms of nutrient loads and dissolved oxygen levels, is unknown, but possibly significant BOD levels may be transported to distant sediment deposition areas upstream (RIDEM, 1992). Due to mixing of water with reverse flow currents in the Warren and Barrington Rivers, there is conjecture that these sources could, under certain conditions, contribute to adverse water quality effects in the Runnins River below the Mobil Dam and in Hundred Acre Cove on the Barrington River (RIDEM 1992, and Shoreline Reappraisal Report, Spring 1990). To what extent, and under what conditions, this may happen has not been quantified.

The ultimate receiving water of the Runnins River is Upper Narragansett Bay, where the Warren River discharges at Adams Point in Barrington. It is a designated conditional shellfishing area, subject to closures following heavy rainfall, due to combined sewer outfall discharges to the Providence and Seekonk Rivers, and nonpoint source pollution. Causes and sources of nonattainment are pathogens, industrial and municipal point source pollution, urban runoff, combined sewer overflows, and others (RIDEM 305b, 1992). Since there are a total of 33 wastewater treatment facility discharge locations and 100 combined sewer outfalls in the entire Narragansett Bay watershed (CCMP 1992), the nonpoint source pollutant load from the Runnins River is probably relatively small compared to total point and non-point source loadings to Narragansett Bay.

(4) <u>Nonpoint Sources</u>. Potential nonpoint sources of contaminants in the Runnins River include runoff from highways, parking lots, farmlands and lawns, landfills, seepage from on-site sewage disposal systems, accidental chemical spills, and resuspension of sediments. Potential nonpoint sources of groundwater pollution are pesticides, fertilizers, septic systems, road salt application, radon, and miscellaneous sources, such as oil spills, and hazardous and toxic waste sites (RIDEM, 1992).

c. <u>Urban Runoff</u>

(1) <u>General</u>. The principal types of pollutants found in urban runoff are sediments, nutrients, oxygen-demanding substances, pathogens, hydrocarbons, heavy metals, and toxics. Detrimental effects of urban runoff are often exacerbated by hydrologic modifications, such as runoff diversion and channelization.

(2) Pathogens. Urban runoff typically contains elevated levels of bacteria and pathogenic organisms. Rainfall can sweep feces, deposited on the ground by pets and domestic animals, wildlife, and waterfowl, directly into streams. High bacteria populations have been found in sheet flow samples from sidewalks, roads, and some bare ground, collected from locations where dogs would most likely be "walked" (Pitt et al., 1994). The presence of pathogens in runoff may result in waterbody impairments such as closed beaches, contaminated drinking water sources, or shellfish bed closings.

Several serious diseases such as typhoid and cholera are caused by enteric (intestinal) bacteria, and it would be very expensive and time consuming to test them all. Instead tests are run for indicator organisms. A good indicator would be an organism that originates in the intestine, that exists in far larger numbers and lasts longer outside the host than pathogens. Coliform bacteria are the most commonly used indicator organisms to give information about the aquatic environment and the possibility that pathogenic organisms may be present. If coliform counts in a body of water are high, there is a greater likelihood that harmful organisms are also present. Obtaining bacterial counts from water samples involves growing the bacteria in cultures in a laboratory process that takes from 1 to 3 days, depending on method used.

Two coliform values are used--fecal and total. Fecal coliforms are principally from feces of warm blooded animals, including humans; total coliforms are from decaying matter as well as feces, and are used as a more conservative measure for things such as finished drinking water. Fecal coliforms are more commonly used to measure the safety of swimming or shellfish harvesting areas. The daily per capita excretion of coliforms is 125 to 400 billion; however, fecal coliforms begin to die off rapidly once they leave their host environment (Clark et al., 1977).

There are some problems with using coliforms as water quality criteria. Water quality effects of fecal coliform contamination are difficult to quantify because no clear correlation exists between numbers and presence of organisms harmful to humans. Moreover, some authorities believe fecal coliform concentrations are not sufficiently conservative as a measure of instream water quality. Other groups of bacteria, such as fecal streptococci, are increasingly being used to indicate fecal pollution.

(3) Septic Systems. Poorly designed or operating systems can cause ponding of partially treated sewage on the ground and can reach surface waters through runoff. In addition to oxygen-demanding organics and nutrients, these surface sources contain bacteria and viruses that present problems to human health. Although groundwater contamination from toxic substances is more often life threatening, the majority of groundwater related health complaints are associated with pathogens from septic tank systems (Yates, 1985). According to Canter and Knox in Septic Tank System Effects on Ground Water Quality:

> In sparsely populated areas, septic systems that have been properly designed, constructed and maintained are efficient and economical alternatives to public sewer disposal systems. However, due to poor locations for many septic tank systems, as well as poor designs and construction and maintenance practices, septic tank systems have polluted, or have the potential to pollute, underlying ground waters. It is estimated that only 40 percent of existing septic tanks function in a proper manner. A major concern in many locations is that the density of the septic tanks is greater than the natural ability of the subsurface environment to receive and purify system effluents prior to their movement in ground water. A related issue is that the design life of many septic tank systems is in the order of 10-15 years.

Since fecal coliform concentrations in septic tank effluents are not markedly reduced relative to average influent levels of 30,000 per 100 ml, the main fecal coliform removal depends on fate and transport through soil after discharge to the leaching field (Canter and Knox, 1985). Canter and Knox summarized results from studies by various researchers of environmental factors that affect the survival of enteric bacteria in soil. The studies show that in properly functioning systems with dry soil conditions, the number of fecal coliform decreases with horizontal distance and depth. However, several environmental factors, including infiltration of unsaturated soils and groundwater movement in saturated soils, can enhance viability of bacteria in soils. Even properly functioning septic systems are viewed as localized groundwater pollution sources since they facilitate the movement of effluent quickly through soil to the groundwater. In addition, low nitrogen

reductions provided by conventional onsite disposal designs have contributed to eutrophication of surface waters.

(4) Existing Development. Maintenance of good water quality is increasingly difficult as more surface area becomes urbanized. Increased peak runoff volumes and pollutant loadings from impervious surfaces permanently alter stream channels, natural drainage ways, and instream and adjacent riparian habitat. Runoff and infiltration from agricultural land, golf courses, and industrial, commercial, and residential land can contribute nutrients and toxic compounds from fertilizers, pesticides, chemical spills, as well as sediments from soil erosion. Freshwater flows due to increased runoff can impact estuaries, especially if they occur in pulses and disrupt the natural salinity of an area.

Parking lots, roads, highways, and bridges concentrate runoff flows and cause erosion and sedimentation problems unless prevented by special measures. In northern climates, where road salt is applied to road surfaces, snow runoff produces high salt concentrations at the bottom of ponds, lakes, and bays. Dead ends of streets, commonly used for piling snow, especially following heavy storms, later release snowmelt carrying sand and salt. Stormwater runoff in erodible bed channels exacerbate erosion and sedimentation problems in wetlands and tributary streams. Suspended sediments, which constitute the largest mass of pollutant loadings to surface water, have both short and long term adverse impacts on surface waters and aquatic life.

High concentrations of organic matter in urban runoff can severely depress dissolved oxygen levels in receiving streams after storm events. Proper levels of dissolved oxygen are critical to maintaining water quality and aquatic life.

Excessive nutrient loadings can result in eutrophication and depressed oxygen levels. Surface discoloration, and the release of toxins from sediments may also concur. Heavy metals and many different toxic compounds, including petroleum hydrocarbons, are also associated with urban runoff.

d. Nonpoint Source Pollution Study. The following is an outline of a nonpoint pollution source study which is meant to define the pollution sources which may be contributing to water quality problems in Hundred Acre Cove and the Runnins River. This study would be meant to identify nonpoint sources and quantify amounts contributed under various conditions in the watershed. The City of East

Providence is not obligated to conduct such a study, nor is it recommended that it be accomplished without addressing the need to undertake such an effort or without further coordination with the towns of Barrington, Rhode Island or Seekonk, Massachusetts.

A nonpoint pollution source study should include a detailed analysis of surface, subsurface, and groundwater flow interactions in the Runnins River, and soil and drainage characteristics of each subbasin. This information should be coupled with an extensive inventory of the various types of nonpoint sources and existing management practices to determine conditions under which each potential source category might be expected to contribute significant pollution. Through use of water quality models, quantitative estimates should be made to evaluate relative amounts, duration, and extent of nonpoint pollution from various sources under various conditions and assumptions. This watershed-specific information should guide the selection of stormwater and wastewater management strategies.

The study should be conducted in phases. Phase 1 would locate broad areas contributing major amounts of pollution, and then Phase 2 would isolate individual sources within these areas. Phase 1 would begin with a survey of storm drains emptying into Hundred Acre Cove during dry and wet weather with simultaneous sampling of the Runnins and Barrington Rivers and Hundred Acre Cove. The purpose would be to determine relative sources of bacteria at the time of contamination in the cove. Phase 2 would investigate drainage areas of either the individual storm drains to the cove, or the Runnins River itself, depending on which is shown to be the major source of contamination. If the Runnins River is shown to be the problem, further investigation would again be phased to include an initial broad delineation of areas from where contamination is coming, followed by an isolation of individual sources within those areas. At each stage in the investigation, if sampling alone does not provide sufficient information to determine the major sources of contamination, a model study may be required. Stormwater modelling of drains, hydrologic and water quality modelling of Runnins River, and tidal modelling of Hundred Acre Cove are the types that may be required.

Costs, provided in the following paragraphs, present an idea of what might be expected once a program is mapped out, but are not considered definitive.

(1) Phase 1. The first phase of study would compare relative amounts of contamination from storm drain outfalls discharging directly to Hundred Acre Cove to amounts from the Runnins and Barrington Rivers. This phase would aid in identifying whether the Runnins River is a primary source of contamination of Hundred Acre Cove. It would require dry and wet weather sampling. A good dry weather sampling period is easy to obtain; however, if wet weather sampling efforts are mobilized for a storm which does not have as much rainfall as forecast, sampling of additional events may be necessary.

In order to allow calculations of flow during wet and dry weather, storm drains will have to be surveyed to determine inverts, slopes, and conditions. Using this information and simple flow equations, depths in the pipes can be related to flow. However, to allow flow estimates during wet weather, water depths in locations away from drain outfalls may need to be measured if backwaters occur during high flows or tides. Direct measurements of flow during wet weather will still be required at some drains to validate use of flow equations, and to compute flows in areas with backwater conditions. Estimated costs for this work would range from $2,000 to $30,000, depending on the quality of available construction plans for these drains.

(a) Dry Weather Monitoring. Outfalls with dry weather flow should be sampled to check for evidence of cross connections or other sources of contamination, possibly involving 10 to 20 samples. If a comprehensive survey of water quality is performed including sampling of coliforms, solids, nutrients, oxygen-demanding substances, and metals, it would cost $10,000 to $20,000. This is the recommended approach; however, if sampling is concentrated exclusively on fecal coliforms, costs might be reduced from $2,000 to $5,000.

If contaminated dry weather flow is observed, it will be necessary to follow with a sanitary survey of the contributing watershed. This should include additional sampling and possible dye testing of septic systems.

(b) Wet Weather Monitoring. During wet weather, outfalls should be sampled when flow increases, and at least twice more when flow is strong. Ideally, they should be sampled at peak flow; however, this is difficult to determine until after the peak has passed. At least one main drain should be monitored over the rising and falling parts of the hydrograph, because the main pollutant load is not necessarily coincident with time of peak runoff; this

probably will require use of an automatic sampler and flow recorder. Additionally, the Runnins and Barrington Rivers need to be sampled over a period of time, spanning the stormwater drain samplings. The sampling plan also needs to consider time of stream travel between stations. The Runnins River needs to be sampled until the peak flow has passed; probably involving sampling every hour for at least 12 hours. The Barrington River needs to be sampled every hour over a rising tide cycle to determine water quality in the tidal flow entering the cove; this will involve 2 or 3 stations on the river, with the furthest well downstream from the cove. Hundred Acre Cove needs to be sampled to determine at what point it becomes contaminated during the storm. As it takes a day before results from coliform analyses are known, sampling in the cove will have to proceed for at least 12 hours at a minimum of two stations.

To determine the relative magnitude of pollutant loadings, a reasonable estimate of flow is required in the Runnins and Barrington Rivers, and individual drains at the times of samplings. Runnins flows would be based on USGS gage results. Barrington River flows might have to be estimated, based on stages in the river and Hundred Acre Cove, and the flows necessary to produce those changes in volumes. Storm drain flows would be based on water depths, supplemented with some direct measurements of flow as previously described.

Finally, dye testing of the Runnins could establish the extent to where this river flows into Hundred Acre Cove during a rising tide. If a storm occurs during a falling tide, it would not be necessary to sample the Barrington River; this sampling could be performed independently of the storm sampling; however, it would be better if it were all done at the same time. Although not necessary at this stage, it would be useful to monitor storm drains in East Providence that discharge to the Runnins River, to allow comparison with drains discharging directly to the cove. Wet weather sampling could cost $50,000 to $130,000, if a full range of water quality parameters are examined in selected samples. If only fecal coliform analyses are performed, costs might be reduced from $10,000 to $25,000 per event. It may be possible to achieve significant cost reductions if volunteers from the PWA or other interested citizen's groups are available.

If results from stormwater sampling do not clearly show that the majority of contamination is coming from either Runnins River or direct drains into Hundred Acre Cove, it may be necessary to extend this first phase to

include stormwater modelling of the drains. This modelling would require determining the layout of the storm drain system, estimating loadings based on land use, determining hydrologic characteristics of the watershed, running a stormwater model such as the Stormwater Management Model "SWMM," and comparing results with observed data. Water quality data collected in the first phase of study would be used to verify the model. If modelling is required, collecting the full range of parameters, rather than just coliform bacteria, would be extremely useful for calibrating the model, because coliform bacteria are among the most difficult parameters to model. The stormwater model would provide a check that the initial sampling was performed at the correct point in the runoff hydrograph. Additionally, it would allow simulation of a variety of storms, including events causing greater loadings of contaminants than sampled ones. It is quite possible that the relative amounts of contamination entering Hundred Acre Cove from direct drains and the Runnins River vary with different intensity and duration storms, but it would be too expensive to sample a wide variety of storms to confirm this. Estimated cost for a stormwater model is $50,000 to $150,000.

(2) Phase 2. The next phase of study would be further investigation of areas identified during Phase 1 as major sources of contamination. Drainage areas would be mapped for storm drains that contribute significant amounts of fecal coliforms. Sanitary surveys of these drainage areas would be required, starting with simple observation of the area, moving into wet weather sampling, and dye testing septic tanks. This would isolate problem areas. Estimated costs would be $10,000 to $20,000, assuming that most contamination is coming from only a few drains. If contamination was widespread among the drains, costs would be greater. Again, use of volunteers could significantly reduce costs.

(3) Runnins River Study. If the river appears to be a major source of contamination to Hundred Acre Cove, as determined in Phase 1, a phased study approach would be used again. Initially, dry and wet weather sampling would be performed in the river, tributaries, and storm drains to identify major con- tributors of pollution. This would be followed by watershed and sanitary surveys to isolate individual sources. However, the costs of this study should be shared among the communities of the watershed.

During the first phase of a Runnins River study, the seven storm drains discharging to the river from East Providence and 11 from Seekonk would be sampled, along with

about a dozen river and tributary stations. Estimated cost for dry and wet weather sampling would be $15,000 to $40,000 if a complete set of water quality parameters are analyzed. Looking at only fecal coliforms might reduce the cost from $3,000 to $7,000, but could result in a poor database if modelling is required. If sampling is mobilized during a storm that produces less precipitation than forecast, additional samplings may be required until a good wet weather event is captured.

If sampling results do not clearly identify subareas within the watershed where the majority of contamination originates, modelling may be required. Stormwater modelling of urban areas, such as East Providence and parts of Seekonk, may be required along with hydrologic and water quality models of less developed areas. Work required would include defining watershed subarea boundaries, determining hydrologic characteristics of these areas, inventorying and mapping storm drains, determining expected pollutant loadings, and developing and running the models. Data collected in initial work, and other previous samplings, would be used to calibrate and verify the model. Although fecal coliform levels may be the main concern, sufficient data on other parameters will be necessary to accurately calibrate models with water quality functions. Estimated modelling costs would range from $100,000 to $300,000.

Once Runnins River watershed subareas, which contribute major pollutant loads, have been identified, Phase 2 of a Runnins River study would isolate sources within those subareas. This will require a sanitary survey including mapping of storm drains, additional wet weather testing, and dye testing of septic systems. The amount of work necessary will depend in part on how much was done in earlier phases. For example, mapping the watershed's storm drains may already have been accomplished if a model study was performed. Estimated costs are $10,000 to $20,000 per subarea watershed.

(4) Barrington River Study. If initial study results from Phase 1 indicate significant coliform concentrations are coming up the Barrington River, extensive sampling and tidal modelling might be required. Tidal modelling to determine mixing in Hundred Acre Cove might be accomplished for $25,000 if existing mapping is determined to be sufficiently accurate. Hydrographic surveys, if necessary, might add another $10,000 to $25,000 to the cost. It is difficult to estimate the modelling and sampling necessary to determine sources to the Barrington River

because it is not known how far into Narragansett Bay the study would extend. However, it is likely that Hundred Acre Cove is receiving contamination from a variety of sources, including, but not limited to, storm drain outfalls discharging into the cove, the Runnins River, or both.

6. STORMWATER MANAGEMENT

a. General. A review of existing stormwater management is important to assess adequacy and recommend improvements. Both Barrington and East Providence have separate sewer collection and storm drainage systems. Seekonk has individual onsite wastewater disposal systems, and little formal stormwater drainage infrastructure in the northern part of town. As typical in the area, municipalities do not assess separate fees for stormwater services and have not formed stormwater utilities. In the watershed communities, Highway and/or Engineering Departments have overall responsibility for drainage, including flooding problems.

To date, municipalities in the study area have not carried out detailed physical inspections of the components of their stormwater drainage systems. Features such as subsurface drains, conduits, drainage swales, wetlands, bridge crossings, and dead ends of streets have not been comprehensively mapped. The municipalities typically plan drainage improvements in conjunction with major road work, and in response to flooding problems. An exception to this approach was recently made by Seekonk, which planned a stormwater infiltration bed project for the sole purpose of mitigating pollution associated with stormwater runoff near Mink Street. The town, assisted by the Southeast Regional Economic Development District, in Taunton, MA., applied for project funding under the Intermodal Surface Transportation Efficiency Act of 1990.

In addition, the City of East Providence, in conjunction with RIDEM, has submitted a Nonpoint Source Management Work Plan to the EPA to obtain funding for a storm drainage retrofit project for paved drainage swales at the River Road crossing of the Runnins River. Additional projects will be included in next years work program.

Other initiatives include the Pokanoket Watershed Alliance's survey of stormwater drainage systems on both shorelines of the Runnins River and an inventory of existing best management measures at various establishments in the Fall River/Highland Avenue commercial district in Seekonk. RIDEM's triennial shoreline surveys for the shellfish

monitoring program include taking fecal coliform samples from drains below Mobil dam.

b. Maintenance Practices. As typical practice for small and medium sized communities, stormwater system maintenance (cleaning catch basins, clearing snagged streams, and street sweeping) is performed on an as needed, rather than routinely scheduled, basis. East Providence disposes of sediments, from cleaning catch basins and winter road operations at the city landfill on Forbes Street, south of the watershed. In the northern part of Seekonk, where there are no catch basins and drains, the Highway Department paved drainage swales to lead runoff into the river, to prevent local street flooding. It is likely this practice increases both the rate and quantity of sediments conveyed to the river.

7. WASTEWATER MANAGEMENT

Barrington and East Providence are sewered and wastewater is treated at East Providence's Pomham Terrace wastewater treatment plant which discharges into the Providence River. The remaining communities in the Runnins River watershed, Seekonk and Rehoboth, MA, are unsewered, but involved in an assessment of their wastewater needs.

Although there are no municipal or industrial wastewater treatment plant discharges to the Runnins River, the wastewater collection system can still affect water quality: through leaking sewer pipes, cross connections, pump station overflows, and lack of sewers. Furthermore, high fecal coliform levels recorded by the PWA in the Warren Avenue tributary and Orange Juice Creek, both in East Providence, indicate that possible sources need to be investigated and ruled out or corrected. Although there are no suspected cross connections in East Providence, it is possible that isolated instances of construction errors, such as connecting a sanitary plumbing line to a storm drain instead of sanitary sewer, remain undetected. It is also possible that isolated East Providence and Barrington residences were not connected to the municipal sewer.

a. East Providence Collection System

(1) General. The city of East Providence's Water Pollution Control Division provides wastewater collections and treatment services for approximately two-thirds of the businesses and residences of East Providence and the entire town of Barrington, under an intermunicipal agreement. The Division is responsible for maintenance of the collection

system, including 19 sewage pumping stations, and the Pomham Terrace wastewater treatment plant (WWTP). Pomham Terrace WWTP, located in the Riverside section of East Providence, discharges 5.5 MGD to the Providence River above Sabin Point. A second WWTP serves northeastern East Providence, but does not belong to the city. The Bucklin Point WWTP is owned and maintained by the regional Narragansett Bay Commission (NBC).

In the past, Seekonk investigated the feasibility of tying in to East Providence's wastewater collection system. However, Pomham Terrace WWTP does not have sufficient capacity to provide both for Seekonk and growth within the city of East Providence (East Providence Comprehensive Plan 1992). In addition, problems with pump station overflows and excessive collection system infiltration have been documented. Among recommendations identified in the East Providence Comprehensive Plan were completion of a Wastewater Facilities Plan Update, determination of financial, physical, and political acceptability of merging with the NBC, and review of the 1973 agreement with Barrington, in regard to a requirement for the town of Barrington to provide a site for sludge disposal. A separate infiltration and inflow study recommended collection system repairs to prevent excessive infiltration.

(2) <u>Pump Station Overflows</u>. Pump station overflows can have significant effects on water quality in the Runnins River watershed; however, they occur only occasionally at one pump station, and as such are not a major problem. Three of East Providence's 19 pump stations are located in the Runnins River watershed, and a fourth is located in the Barrington watershed.

Fecal coliform data collected during one particular overflow event demonstrate the magnitude of effects on water quality. In April 1993, collection system personnel from East Providence's Water Pollution Control Division, discharged chlorinated overflows from pump station 16, Wannamoisett Road Pump Station, located at the dead end of Wannamoisett Road, into Orange Juice Creek, a tributary to the Runnins River. Discharges occurred between 1 to 4 April 1993. In one event, 60,000 gallons were released in 16 hours, and, in the second, 125,000 gallons were released in 31 hours. A total of 17 gallons of hypochlorite was used. The discharges were necessary to protect electric pump motors from being submersed by station flooding caused by a force main break (letter by East Providence to RIDEM, 27 April 1993).

These, and earlier discharges at this station were also reported by passersby, and documented by Doug Rayner, affiliated with the Pokanoket Watershed Alliance. According to Mr. Rayner, in addition to the April event, discharges also occurred in early December 1992 and 26 February 1993. On 1 April, Mr. Rayner sampled Orange Juice Creek at Catamore Boulevard at 8 a.m. and School Street bridge at 8:20 a.m., as precipitation was beginning. He found <1 per 100 ml at Catamore Boulevard and 120 per 100 ml at School Street. He returned to the pump station at 12:30 p.m., after moderate to heavy rainfall, and found the discharge manhole cover removed and a submersible pump, discharging sewage at approximately 60 gallons per minute. Analysis of samples taken at Catamore Boulevard at 12:50 p.m., and at School Street Bridge at 1 p.m., indicated 22,000 and 8,000 per 100 ml, respectively.

(3) Infiltration/Inflow Analysis. Infiltration and inflow (I/I) studies were examined to give a general condition of the collection system. Of interest is whether exfiltration of raw sewage from broken pipes could discharge to groundwater and eventually the Runnins River. I/I studies typically do not address exfiltration explicitly, as they are conducted to demonstrate that the sewer system is not discharging excessive I/I to wastewater treatment works that were constructed with Federal money under the Wastewater Construction Grants Program (City of East Providence, August 1988).

East Providence commissioned Hayden/Wegman Consulting Engineers to study if excessive I/I exists in its wastewater collection system. The August 1988 report defines infiltration as ground water entering a sewer system and service connections through defective pipes, pipe joints, connections, or manhole walls; and inflow as surface water entering from sources such as manhole covers and broken pipes. Other illegal but often significant sources of inflow include roof leaders, basement and yard drains, and cross connections from sanitary sewer lines.

The study concluded that large amounts of infiltration exists in some drainage areas, including portions in the Runnins River watershed. Amount of infiltration is dependent on the groundwater table, and sewer flow rates remained elevated until the groundwater table dropped below sewer elevations. Inflow was not found to be a significant problem. Since, under some conditions, excessive infiltration areas can also be susceptible to exfiltration, this potential source of fecal coliform contamination should be

further investigated, and either ruled out, or corrected by making repairs recommended by the I/I study.

b. Seekonk Needs Assessment. Seekonk is not sewered and is having some difficulties with residential and commercial subsurface disposal systems. It is considering implementing some form of sewer system versus septic tank system management. There is not enough information to evaluate the effects septic systems are having on the river. According to the most up-to-date wastewater facilities plan, some type of sewer system would be required to deal most effectively with the town's problems.

A draft Facilities Plan for Wastewater Management was prepared for the town of Seekonk by Keyes Associates in 1981. It reviewed existing wastewater disposal practices and effects on groundwater quality, presented a detailed onsite disposal system evaluation of approximately ten subareas, and included development of alternatives, preliminary design information, and an implementation plan. Appendices include survey data, USGS groundwater data, subsurface investigation data, and guidelines for avoidance of adverse environmental impacts.

The following are major findings and recommendations of the Facilities Plan which pertain to the Runnins River study area:

(1) In South Seekonk, in an area known locally as Fieldwood and Briarwood, high groundwater and marginal soil conditions are the chief cause of problems from existing onsite septic disposal systems.

(2) System failures in fully developed areas of North Seekonk are mainly due to older cesspool systems affecting groundwater quality. Both soil characteristics and groundwater levels are generally suitable for modern subsurface disposal systems in this area. Upgrading, rehabilitation, and replacement of problem systems are recommended.

(3) Throughout the remainder of town, failures are not clustered to the degree evident in the areas referenced above.

(4) The Highland Avenue area in South Seekonk has experienced some disposal problems. Both soil and groundwater characteristics are suitable for continued use of subsurface disposal systems. Apparent problems appear

related to system sizing and use, rather than site restrictions.

The draft Facilities Plan concluded that the most cost effective and environmentally acceptable plan would be a combination of group or cluster disposal systems, fed by small diameter gravity sewers to serve a portion of the area, and rehabilitation of certain individual systems throughout the remainder (Town of Seekonk, 1981).

In contrast to concerns about septic systems in residential areas identified in the draft Wastewater Facilities Plan and in the adjacent Palmer River watershed (see section 4j), a survey of septic systems management practices of 30 businesses in the Fall River/Highland Avenue area showed that the majority of these onsite wastewater disposal systems at commercial establishments are presently functioning with little or no problems. Purpose and results are described in a Letter Report on Status of Work Performed Under Amendment No. 2 (September 1992), prepared by Fay, Spofford, and Thorndike, Inc., Engineers, dated 17 February 1993.

The survey showed that five or six establishments had problems in the past with their disposal systems due to infrequent cleaning of septic tanks and grease traps. A large proportion of pumpings were associated with grease traps, not cesspools or septic tanks; and a high frequency of grease trap pumping is desirable for proper maintenance of systems handling elevated grease and solids concentrations. Repairs to onsite systems were largely the result of business expansions. One area of concern for large commercial establishments, as well as future business development in the Fall River/Highland Avenue area, is a proposed change to Title 5 of the Massachusetts State Environmental Code, whereby the maximum wastewater flow, which can be disposed without a groundwater discharge permit, will be reduced.

MADEP's Bureau of Municipal Facilities Management is coordinating the town's ongoing needs assessment as part of regional wastewater facilities planning process that includes septage disposal management. Some proposals made to date, but not necessarily supported, include a joint effort with Rehoboth, MA, to site a package wastewater treatment plant, connecting to Attleboro's publicly owned WWTP, or tying into East Providence's wastewater collection system.

8. RECOMMENDATIONS

a. General. This study found that Runnins River water quality is quite poor and does not meet the goals of being fishable and swimmable. Fecal coliform contamination is the main problem in Runnins River and Hundred Acre Cove. However it is not clear that the coliforms contaminating Hundred Acre Cove come solely from the Runnins River. Shoreline surveys have identified 30 storm drains discharging directly into Hundred Acre Cove from Barrington. Finally, it is even possible that significant contamination comes up the Barrington River on rising tidal flows. Sources of bacteria contaminating the Cove need to be identified before they can be remediated.

b. City of East Providence. This section focuses on what the city of East Providence could do to prepare for Phase II of the 402(p) stormwater permit program and the State Coastal Zone Nonpoint Source Pollution Program. Although formulation of specific requirements and guidelines have not been completed, these will be forthcoming shortly. Therefore, the city could encourage Budget, Engineering, and Planning Department personnel to attend seminars on urban stormwater runoff and nonpoint source pollution.

The experience of other cities, which have applied for a municipal stormwater permit under Phase I of the 402(p) program, could be drawn upon to plan and budget engineering services that may be needed to comply with program requirements. The cities of Providence and Boston are both exempt from Phase I because they have combined sanitary and storm sewers. However, Worcester, MA., has applied for a municipal stormwater discharge permit under Phase I; more than 100,000 people are served by its separate stormwater drainage system.

Also in anticipation of Phase II of the 402(p) stormwater permit program, the city could identify, inspect, inventory and periodically check all sources of stormwater, sewage, and industrial wastes. The first component of this task would be to review existing stormwater drainage system records. All stormwater system components, such as conduits, catch basins, drainage swales, wetlands, channels, and tributaries would be identified in each drainage subbasin (see Hydrologic Appendix B). The city could comprehensively map the existing drainage system for the purpose of planning drainage system maintenance and priority improvement projects. The city could conduct an investigation of inappropriate pollutant entries into storm drainage systems to quantify and identify the pollutant load from its

stormwater discharges to the Runnins River (USEPA Publication No. 600/R-92/238, January 1993).

The East Providence Division of Water Pollution Control could check all sewer service areas to definitively determine that residences, industries, and commercial establishments are properly connected to the municipal sewer system and to identify nonservice areas. This type of an investigation could be conducted in connection with the sewer rate study envisioned by the East Providence Comprehensive Plan, and cost effective repairs to the collection system recommended by Hayden/Wegmans Consulting Engineers, for the purpose of stopping large amounts of infiltration (City of East Providence, August 1988). Furthermore, repairs to the Wannamoisett Road pump station and force main should be documented.

The city of East Providence could compile and consolidate existing data on groundwater levels and soil conditions which were collected during design and construction of municipal facilities in the Runnins River watershed. Soil conditions and depth to the water table are critical inputs to proper design and siting of structural best management practices, should these be considered to meet program objectives. Data gaps should be identified so that additional investigations can be targeted, as needed. Knowledge of site conditions is likely to be a significant factor in the evaluation of structural (infiltration trenches, detention basins) versus nonstructural (zoning and buffer strips) best management practices.

In anticipation of the State Coastal Zone Nonpoint Source Pollution program, the city could contact other municipalities which discharge stormwater to coastal and near coastal waters. For example, the Cape Cod communities of Barnstable and Orleans, MA, recently initiated stormwater management programs to reverse fecal coliform contamination in shellfish growing areas. Both communities, for the most part are sewered and attribute high fecal coliform levels to stormwater runoff.

c. Regional Coordination. A comprehensive nonpoint source study will require regional coordination, although some elements could be accomplished independently. The city could support further efforts to better understand water quality impacts in the watershed under at least three antecedent soil saturation and weather conditions: high riverflow and high groundwater level, low river flow and high groundwater level, and low river flow and low ground-

water level. It is possible that the town of Seekonk may expand its wastewater needs assessment study to the Runnins River watershed, using the methodology of the area 5, Palmer River watershed effort.

The city could continue its involvement with the NEIWPCC Runnins River Initiative proposals. The city is presently a member of the Steering Committee and the Technical Review Committee. The city could continue to propose and support projects, such as continuing to provide assistance and support to the Pokanoket Watershed Alliance. Currently, the PWA has proposed additional gaging of flow, intensive sampling in the reach between Highland Avenue (State Route 6) and Mink Street, dye testing of commercial and residential septic systems by State and town Health officials, and review of existing subsurface investigation for the purpose of locating potential preferential subsurface drainage paths, by which fecal coliform may be conveyed from septic disposal systems to the Runnins River.

The city could also encourage RIDEM to include the Runnins River in existing Statewide chemical and biological monitoring programs. Ideally, sampling data by the Pokanoket Watershed Alliance and NEIWPCC Runnins River Initiative would supplement, not replace, participation in a Statewide monitoring program. Of course, additional sampling for specific tasks, such as dye-testing septic systems, should be used to identify and locate particular sources. However, because trend monitoring and statistical analysis that can be performed with alternative sampling programs is limited, these should not take the place of baseline monitoring. Alternative sampling programs are presented in nonstandard reporting formats relative to the Statewide program. Also, since they usually depend on grant approvals and are time-limited, they may be subject to delays and inadequate data interpretation because of dependence on volunteers or staff changes. Different sampling frequencies, stations, and quality control and analytical procedures result in incompatible results being produced. The lack of compatible data and water quality data qualifiers could impair effective cooperation to seek competitive funds and develop feasibility and performance criteria for best management measures.

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RUNNINS RIVER WATERSHED
STORM WATER MANAGEMENT STUDY
EAST PROVIDENCE, RHODE ISLAND

WATER QUALITY ASSESSMENT

Photo 1: Pond south of Walnut Street, Seekonk. Algae blooms indicate presence of high nutrient levels.

Photo 2: Looking upstream from Prospect Street, Seekonk. Example of individual on-site septic system in close porximity to main channel.

Photo 3: Erosion problems at intersection of Arcade Avenue and Ledge Street, Seekonk. Area drains to Runnins River tributary.

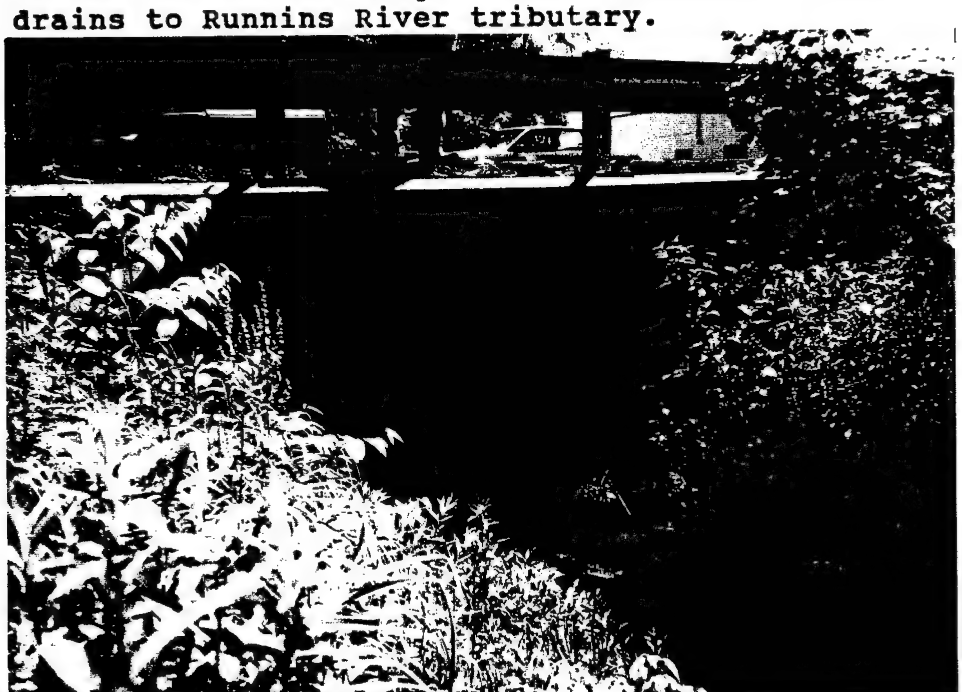


Photo 4: Upstream face of Taunton Avenue (US Route 44) Bridge, Seekonk. One of approximately 14 bridge or culvert crossings.

Photo 5: USGS Gage, upstream face of Pleasant Street Bridge, Seekonk

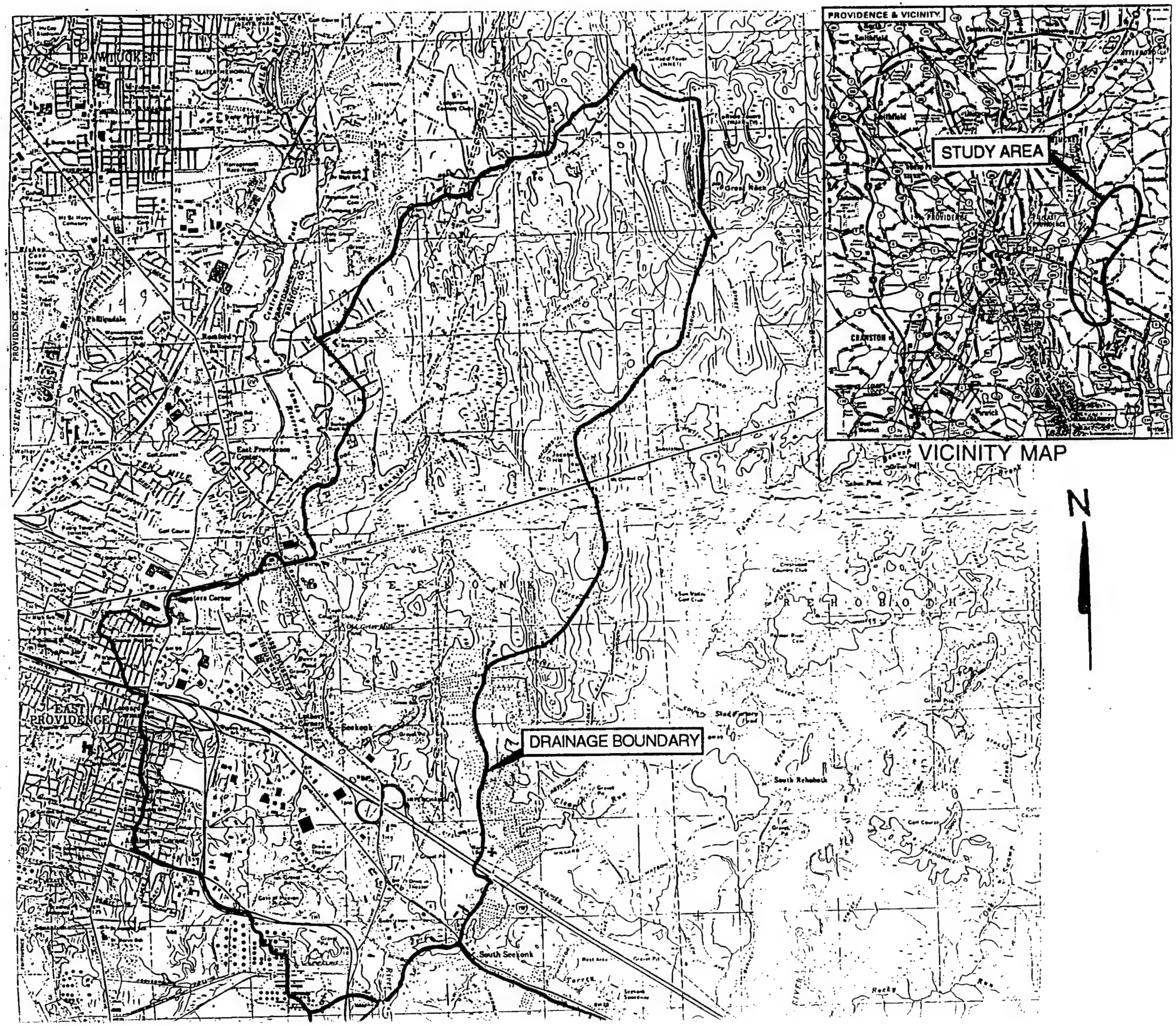
Photo 6: Old Grist Mill Pond on Arcade Avenue, Seekonk

Photo 7: Looking upstream from Highland Avenue (US Route 6) Bridge, Seekonk

Photo 8: Paved Drainage Swale, School Street (stateline)

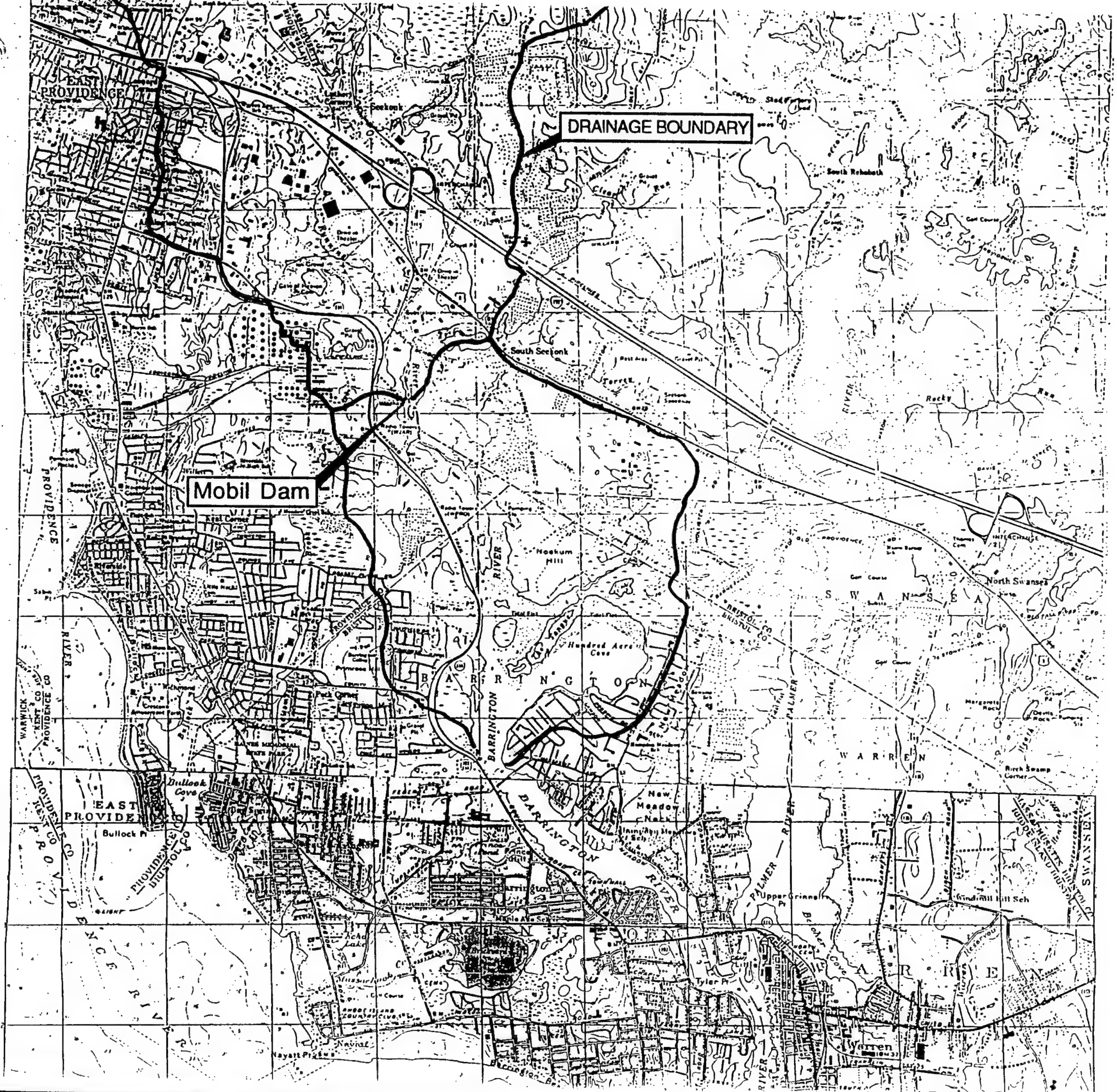
Photo 9: Wampanoag Trail (State Route 114), East Providence. No sediment and erosion controls on outside northbound lane. Mobil Oil Corporation property in background.

Photo 10: Barrington River, Hundred Acre Cove in background, Barrington

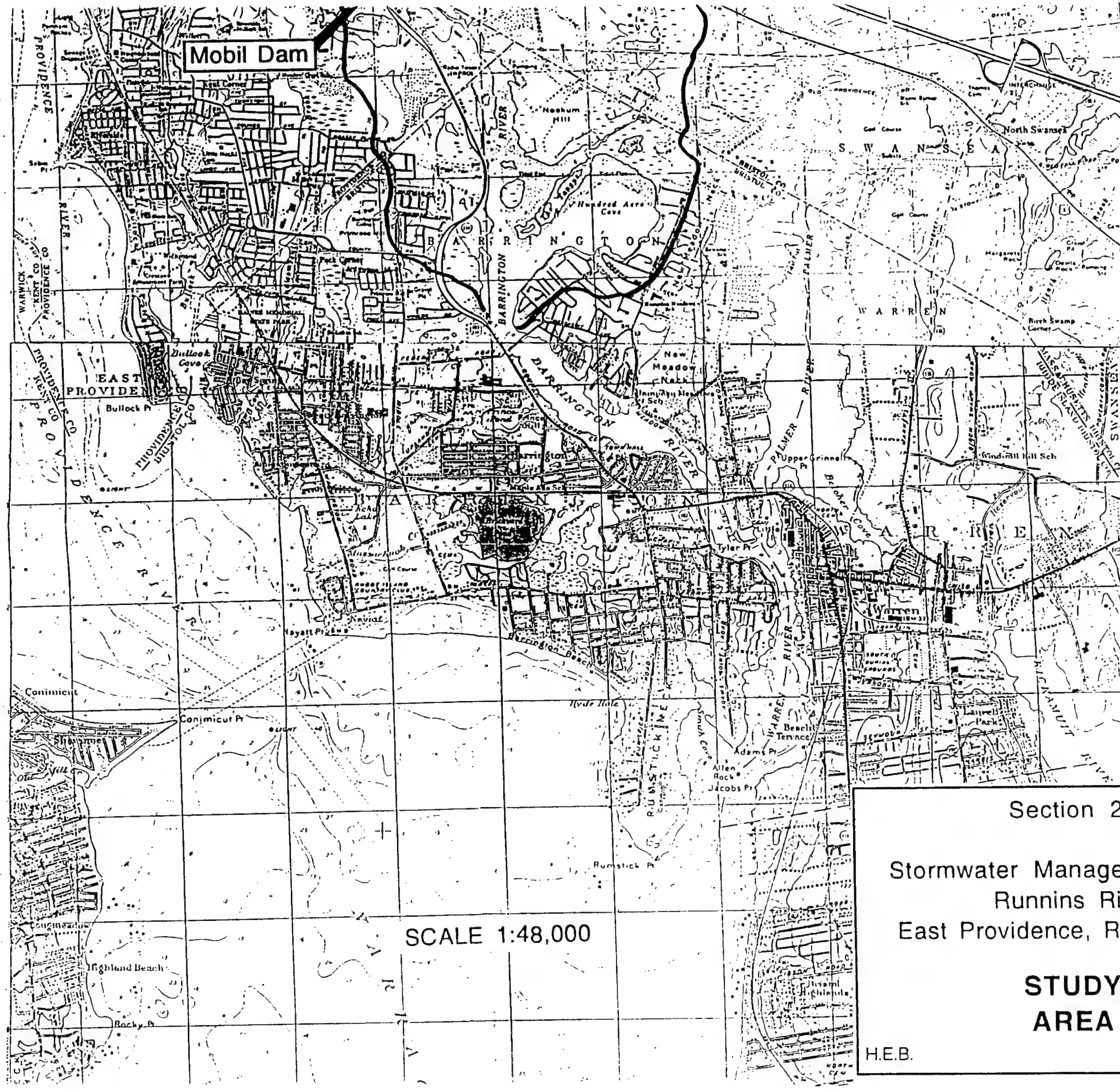


PROVIDENCE & VICINITY
STUDY AREA
VICINITY MAP
N
DRAINAGE BOUNDARY
PAWTUCKET
EAST PROVIDENCE
SEEKONK
REHOBOTH
South Seekonk
South Rehoboth

1



DRAINAGE BOUNDARY
Mobil Dam
EAST PROVIDENCE
South Seekonk
South Rehoboth
Hundred Acre Cove
Hockum Hill
BARRINGTON
BARRINGTON RIVER
New Meadow Neck
SWANSEA
North Swansea
WARREN
PALMER RIVER
Belcher Cove
Bullock Cove
Bullock Pt
PROVIDENCE RIVER
Nayatt Pt
Warren
Windmill Hill Sch



Section 22

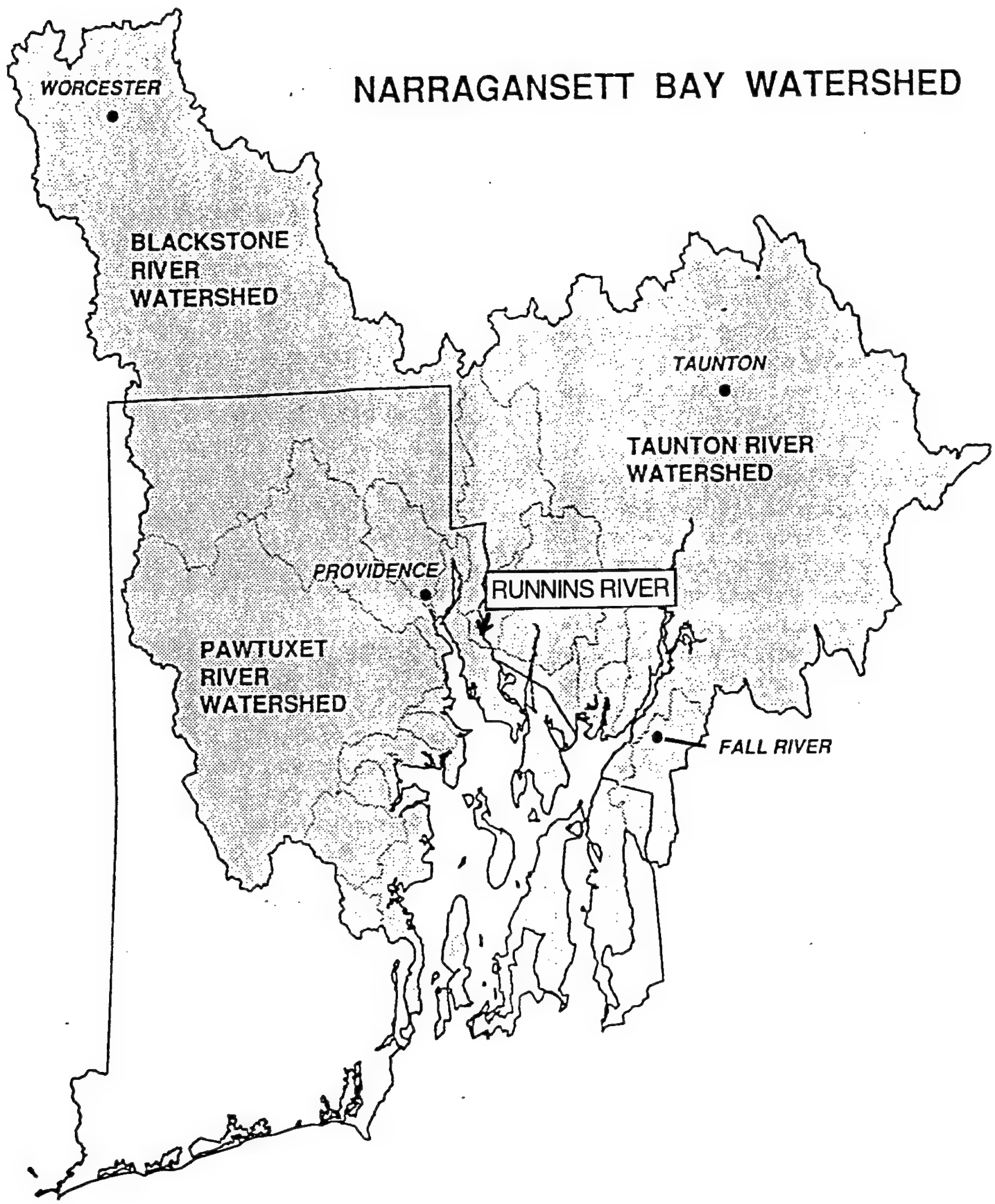
Stormwater Management Study
Runnins River
East Providence, Rhode Island

**STUDY
AREA**

H.E.B. Feb 19

3

PLATE 1



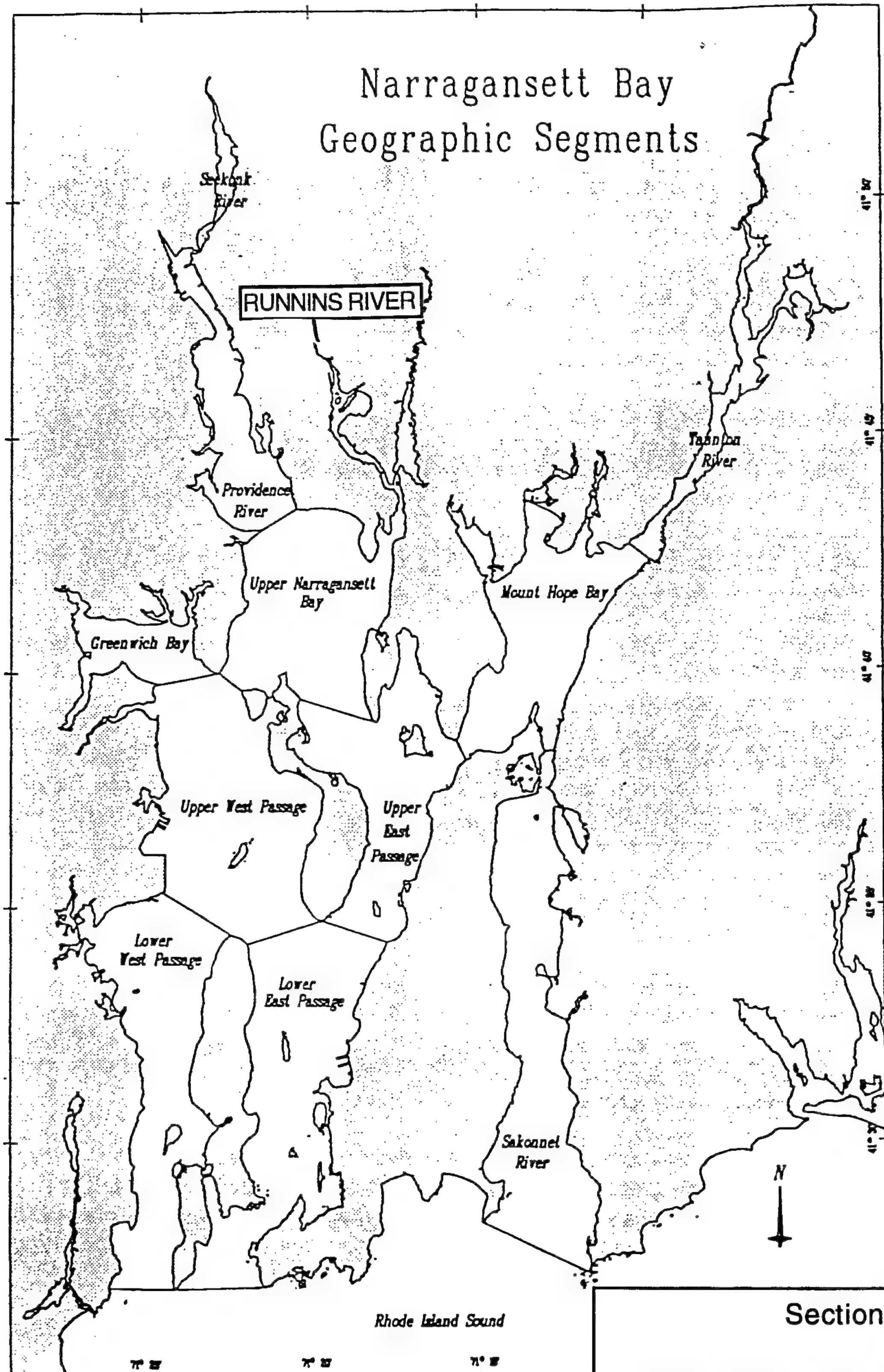
SOURCE: RIGIS

Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

NARRAGANSETT BAY WATERSHED

E.E.H.B. PLATE 2 MARCH 1994



SOURCE: RIGIS

Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

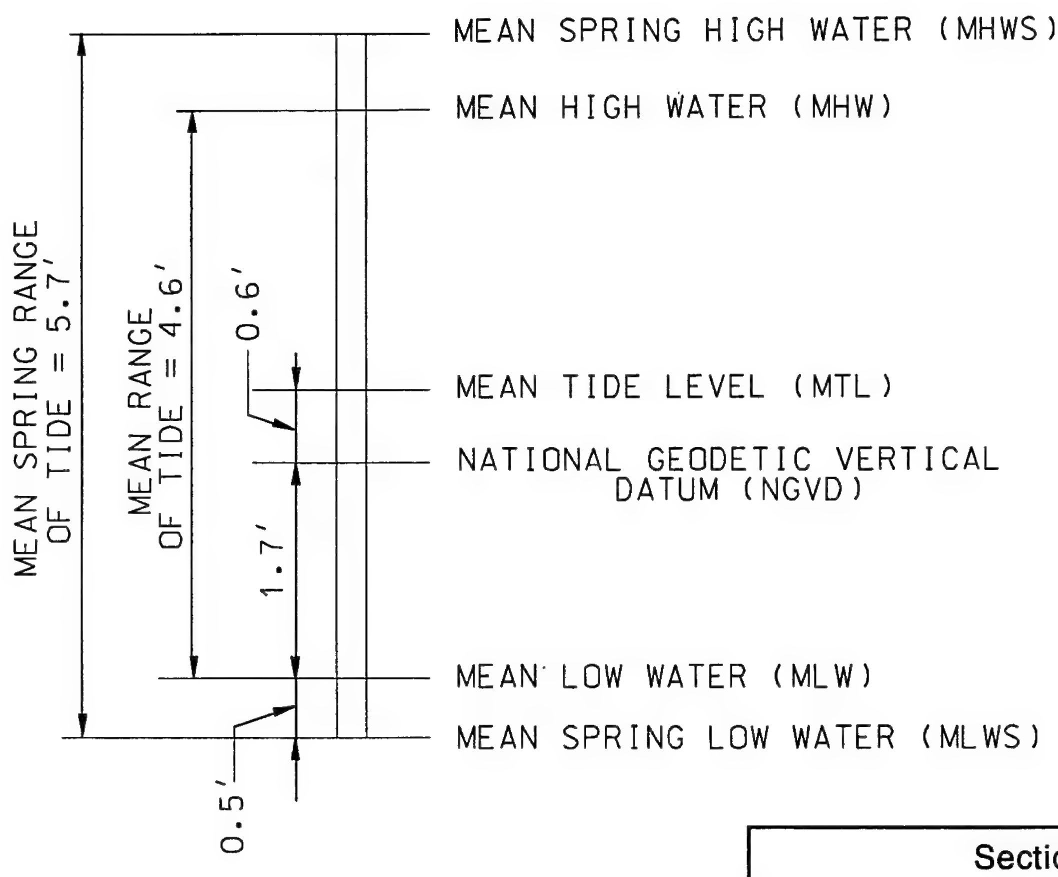
NARRAGANSETT BAY GEOGRAPHIC SEGMENTS

E.E.H.B. PLATE 3 MARCH 1994

PLATE 4

TIDAL DATUM PLANES
WARREN, RHODE ISLAND

(BASED UPON NATIONAL
OCEAN SURVEY TIDAL
BENCHMARK DATA
FOR 1960 - 78 TIDAL EPOCH)

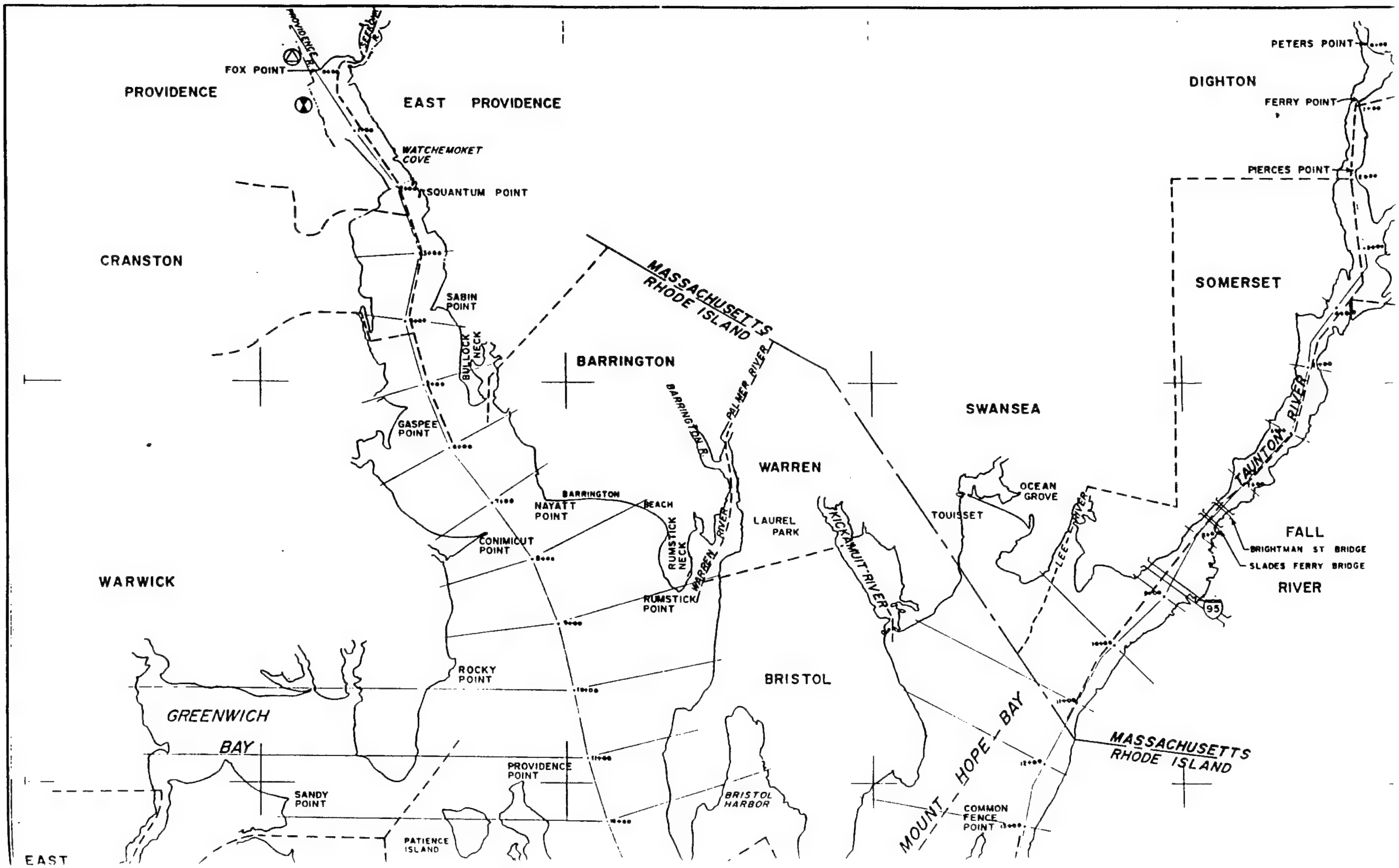


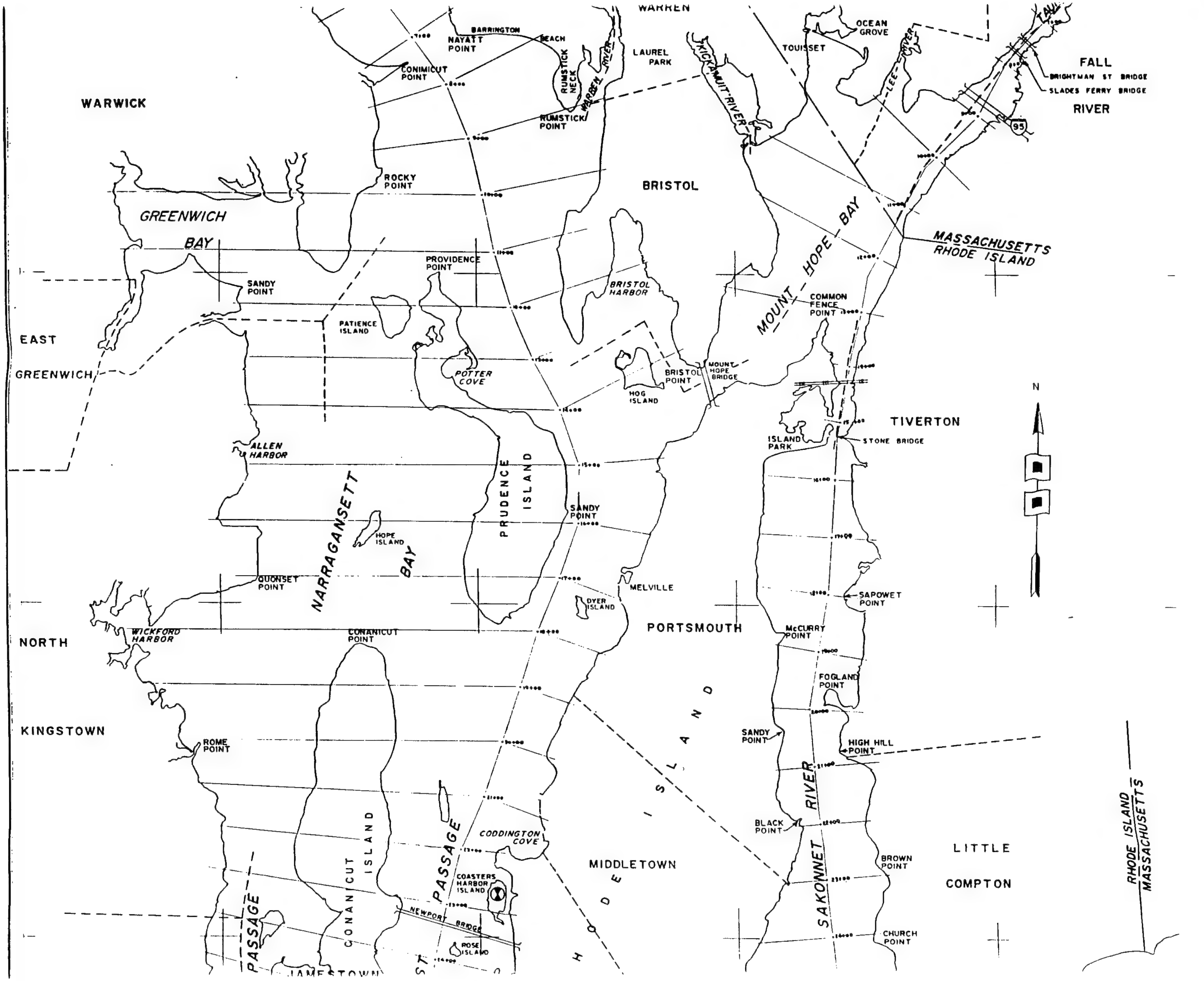
Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

TIDAL DATUM PLANES, WARREN, RHODE ISLAND

E.E.H.B. PLATE 4 March 1994


PROVIDENCE
FOX POINT
PROVIDENCE R.
SEEKONK R.
EAST PROVIDENCE
WATCHEMOKET COVE
SQUANTUM POINT
CRANSTON
SABIN POINT
BULLOCK NECK
GASPEE POINT
BARRINGTON
MASSACHUSETTS
RHODE ISLAND
BARRINGTON R.
PALMER RIVER
BARRINGTON BEACH
NAYATT POINT
CONIMICUT POINT
RUMSTICK NECK
WARREN RIVER
RUMSTICK POINT
WARREN
LAUREL PARK
WARWICK
ROCKY POINT
GREENWICH BAY
SANDY POINT
PROVIDENCE POINT
PATIENCE ISLAND
BRISTOL
BRISTOL HARBOR
KICKAMUIT RIVER
SWANSEA
TOUISSET
OCEAN GROVE
LEE RIVER
MOUNT HOPE BAY
COMMON FENCE POINT
DIGHTON
PETERS POINT
FERRY POINT
PIERCES POINT
SOMERSET
TAUNTON RIVER
FALL RIVER
BRIGHTMAN ST BRIDGE
SLADES FERRY BRIDGE
95
EAST


WARWICK
WARREN
BARRINGTON
NAYATT POINT
BEACH
CONIMICUT POINT
RUMSTICK NECK
WARREN RIVER
RUMSTICK POINT
LAUREL PARK
KICKAMUIT RIVER
TOUISSET
OCEAN GROVE
LEE RIVER
FALL RIVER
BRIGHTMAN ST BRIDGE
SLADES FERRY BRIDGE
95
ROCKY POINT
BRISTOL
GREENWICH BAY
MASSACHUSETTS
RHODE ISLAND
MOUNT HOPE BAY
PROVIDENCE POINT
SANDY POINT
BRISTOL HARBOR
COMMON FENCE POINT
EAST GREENWICH
PATIENCE ISLAND
POTTER COVE
BRISTOL POINT
MOUNT HOPE BRIDGE
HOG ISLAND
N
TIVERTON
ISLAND PARK
STONE BRIDGE
ALLEN HARBOR
NARRAGANSETT BAY
PRUDENCE ISLAND
SANDY POINT
HOPE ISLAND
QUONSET POINT
MELVILLE
DYER ISLAND
SAPOWET POINT
NORTH KINGSTOWN
WICKFORD HARBOR
CONANICUT POINT
PORTSMOUTH
McCURRY POINT
FOGLAND POINT
RHODE ISLAND
SANDY POINT
HIGH HILL POINT
ROME POINT
SAKONNET RIVER
BLACK POINT
CODDINGTON COVE
PASSAGE
CONANICUT ISLAND
MIDDLETOWN
BROWN POINT
LITTLE COMPTON
COASTERS HARBOR ISLAND
NEWPORT BRIDGE
ROSE ISLAND
PASSAGE
JAMESTOWN
CHURCH POINT

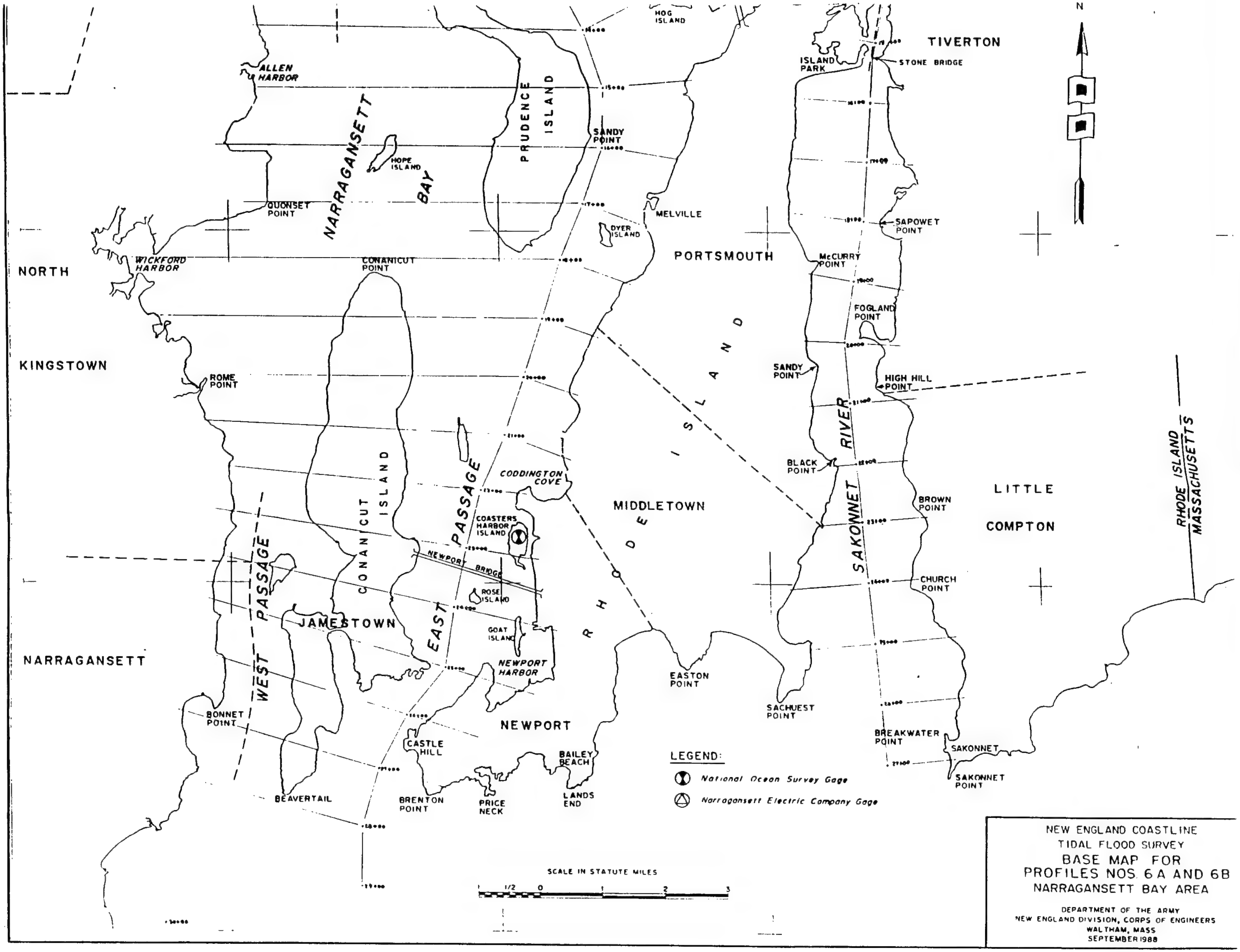
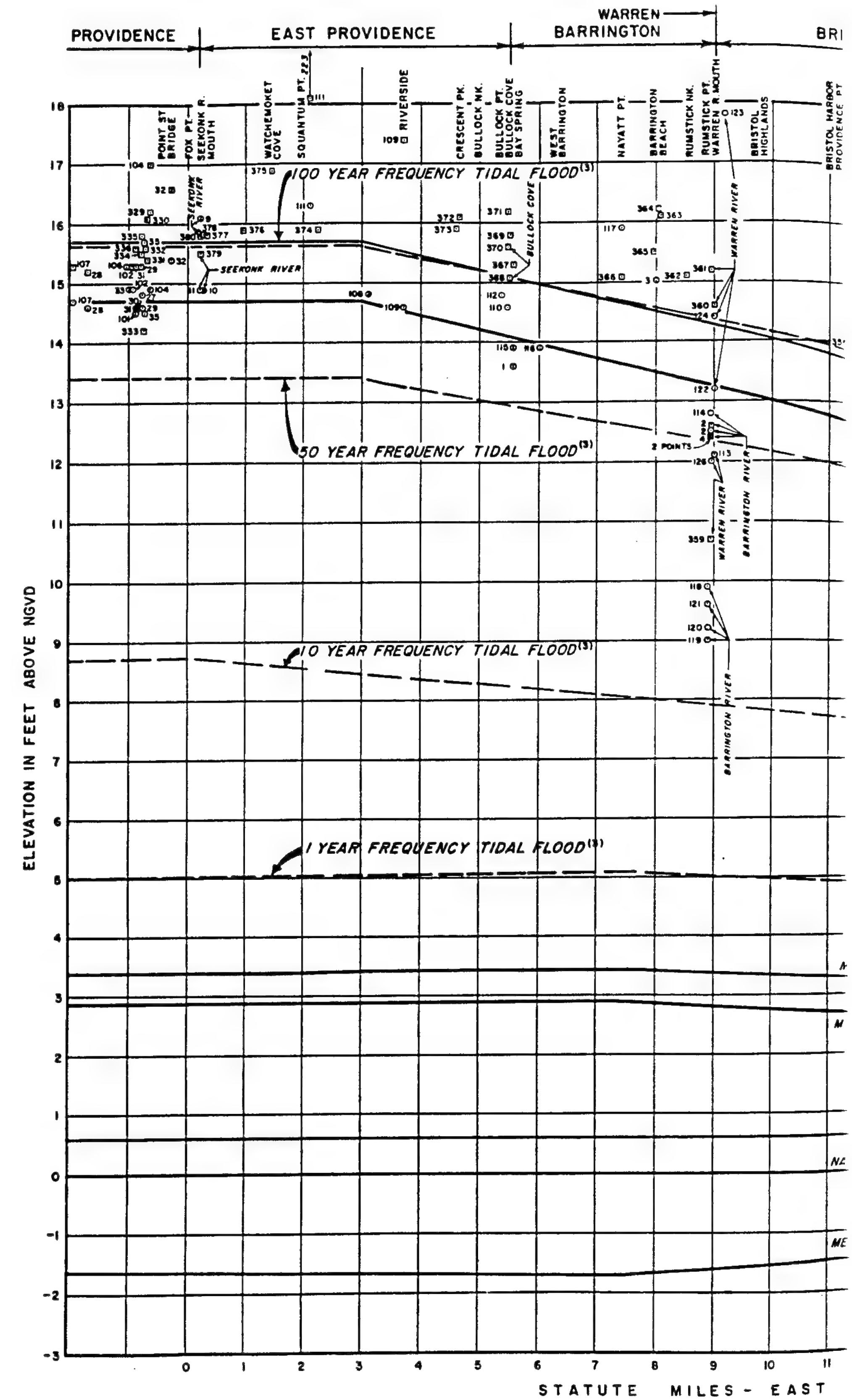
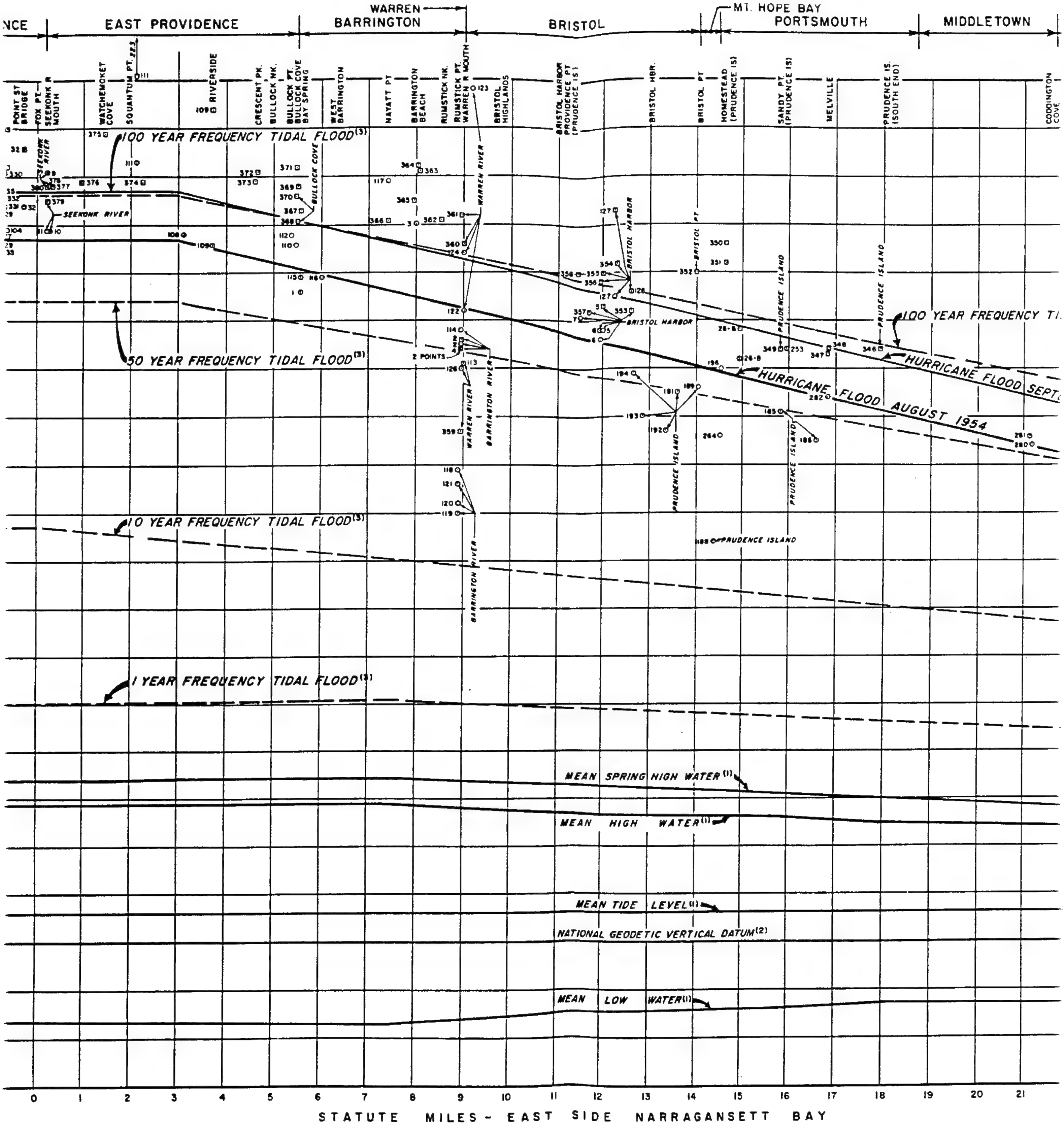

NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
BASE MAP FOR
PROFILES NOS. 6 A AND 6 B
NARRAGANSETT BAY AREA
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS
SEPTEMBER 1988
LEGEND:
National Ocean Survey Gage
Narragansett Electric Company Gage
SCALE IN STATUTE MILES
1/2
0
1
2
3
N
TIVERTON
STONE BRIDGE
ISLAND PARK
HOG ISLAND
ALLEN HARBOR
NARRAGANSETT
BAY
HOPE ISLAND
PRUDENCE ISLAND
SANDY POINT
MELVILLE
DYER ISLAND
QUONSET POINT
WICKFORD HARBOR
CONANICUT POINT
NORTH
KINGSTOWN
PORTSMOUTH
SAPOWET POINT
McCURRY POINT
FOGLAND POINT
SANDY POINT
HIGH HILL POINT
BLACK POINT
SAKONNET RIVER
RHODE ISLAND
MASSACHUSETTS
LITTLE
COMPTON
BROWN POINT
CHURCH POINT
ROME POINT
CONANICUT ISLAND
EAST PASSAGE
CODDINGTON COVE
MIDDLETOWN
COASTERS HARBOR ISLAND
NEWPORT BRIDGE
ROSE ISLAND
GOAT ISLAND
NEWPORT HARBOR
JAMESTOWN
WEST PASSAGE
NARRAGANSETT
BONNET POINT
BEAVERTAIL
CASTLE HILL
BRENTON POINT
PRICE NECK
NEWPORT
BAILEY BEACH
LANDS END
EASTON POINT
SACHUEST POINT
BREAKWATER POINT
SAKONNET
SAKONNET POINT

PLATE 5

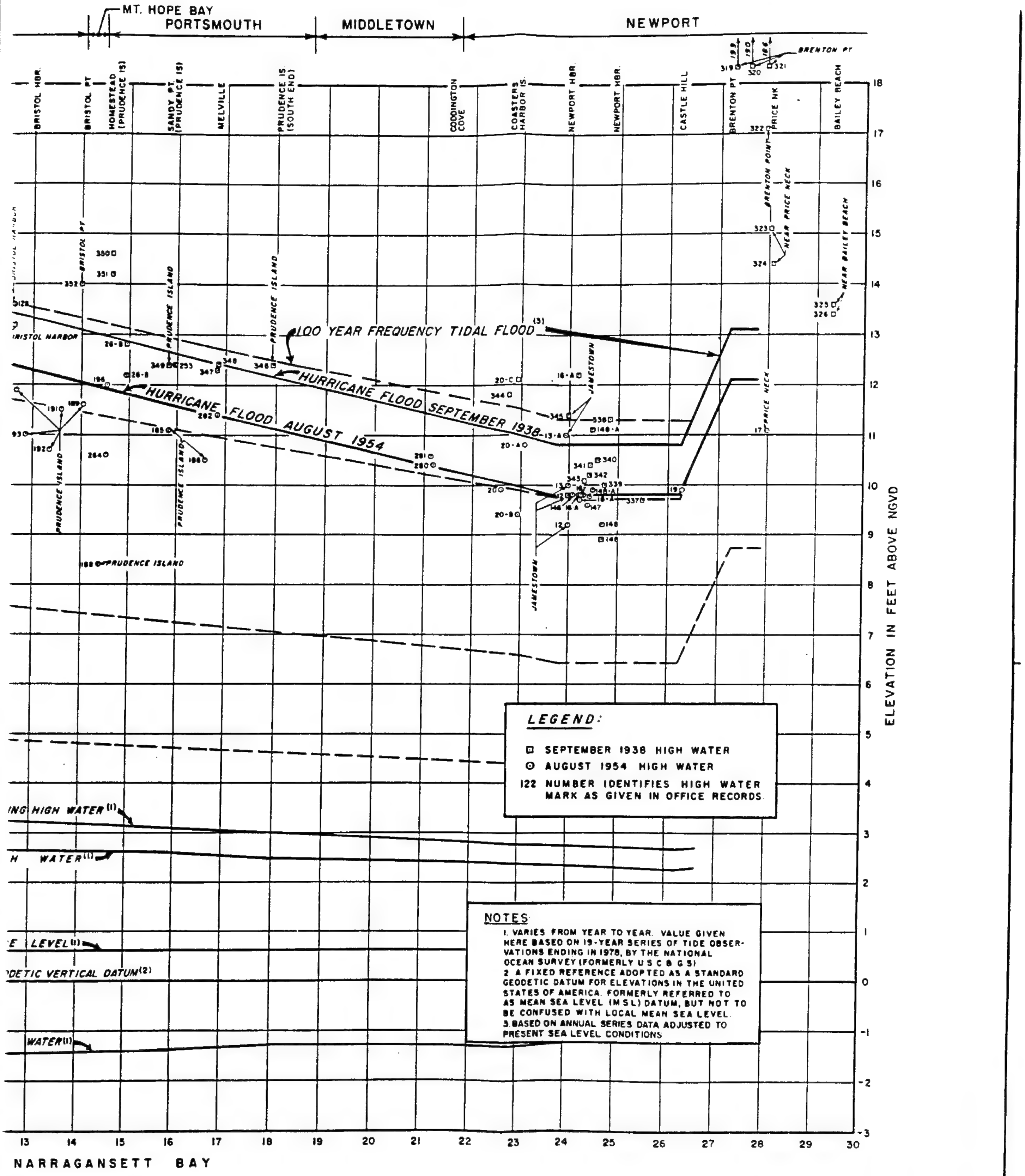


PROVIDENCE
EAST PROVIDENCE
WARREN
BARRINGTON
BRI
POINT ST BRIDGE
FOX PT.
SEEKONK R. MOUTH
WATCHEMOKET COVE
SQUANTUM PT.
RIVERSIDE
CRESCENT PK.
BULLOCK NK.
BULLOCK PT.
BULLOCK COVE
BAY SPRING
WEST BARRINGTON
NAYATT PT.
BARRINGTON BEACH
RUMSTICK NK.
RUMSTICK PT.
WARREN R. MOUTH
BRISTOL HIGHLANDS
BRISTOL HARBOR
PROVIDENCE PT
100 YEAR FREQUENCY TIDAL FLOOD(3)
50 YEAR FREQUENCY TIDAL FLOOD(3)
10 YEAR FREQUENCY TIDAL FLOOD(3)
1 YEAR FREQUENCY TIDAL FLOOD(3)
SEEKONK RIVER
BULLOCK COVE
WARREN RIVER
BARRINGTON RIVER
2 POINTS
ELEVATION IN FEET ABOVE NGVD
STATUTE MILES - EAST



NCE
EAST PROVIDENCE
WARREN
BARRINGTON
BRISTOL
MT. HOPE BAY
PORTSMOUTH
MIDDLETOWN
POINT ST BRIDGE
FOX PT. SEEKONK R. MOUTH
WATCHEMOKET COVE
SQUANTUM PT.
RIVERSIDE
CRESCENT PK.
BULLOCK NK.
BULLOCK PT. BULLOCK COVE BAY SPRING
WEST BARRINGTON
NAYATT PT
BARRINGTON BEACH
RUMSTICK NK.
RUMSTICK PT. WARREN R MOUTH
BRISTOL HIGHLANDS
BRISTOL HARBOR PROVIDENCE PT (PRUDENCE IS)
BRISTOL HBR.
BRISTOL PT
HOMESTEAD (PRUDENCE IS)
SANDY PT. (PRUDENCE IS)
MELVILLE
PRUDENCE IS. (SOUTH END)
CODDINGTON COVE
100 YEAR FREQUENCY TIDAL FLOOD(3)
SEEKONK RIVER
BULLOCK COVE
WARREN RIVER
BRISTOL HARBOR
BRISTOL PT
PRUDENCE ISLAND
100 YEAR FREQUENCY TI
HURRICANE FLOOD SEPT
HURRICANE FLOOD AUGUST 1954
50 YEAR FREQUENCY TIDAL FLOOD(3)
2 POINTS
BARRINGTON RIVER
10 YEAR FREQUENCY TIDAL FLOOD(3)
1 YEAR FREQUENCY TIDAL FLOOD(3)
MEAN SPRING HIGH WATER(1)
MEAN HIGH WATER(1)
MEAN TIDE LEVEL(1)
NATIONAL GEODETIC VERTICAL DATUM(2)
MEAN LOW WATER(1)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
STATUTE MILES - EAST SIDE NARRAGANSETT BAY

2



NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY

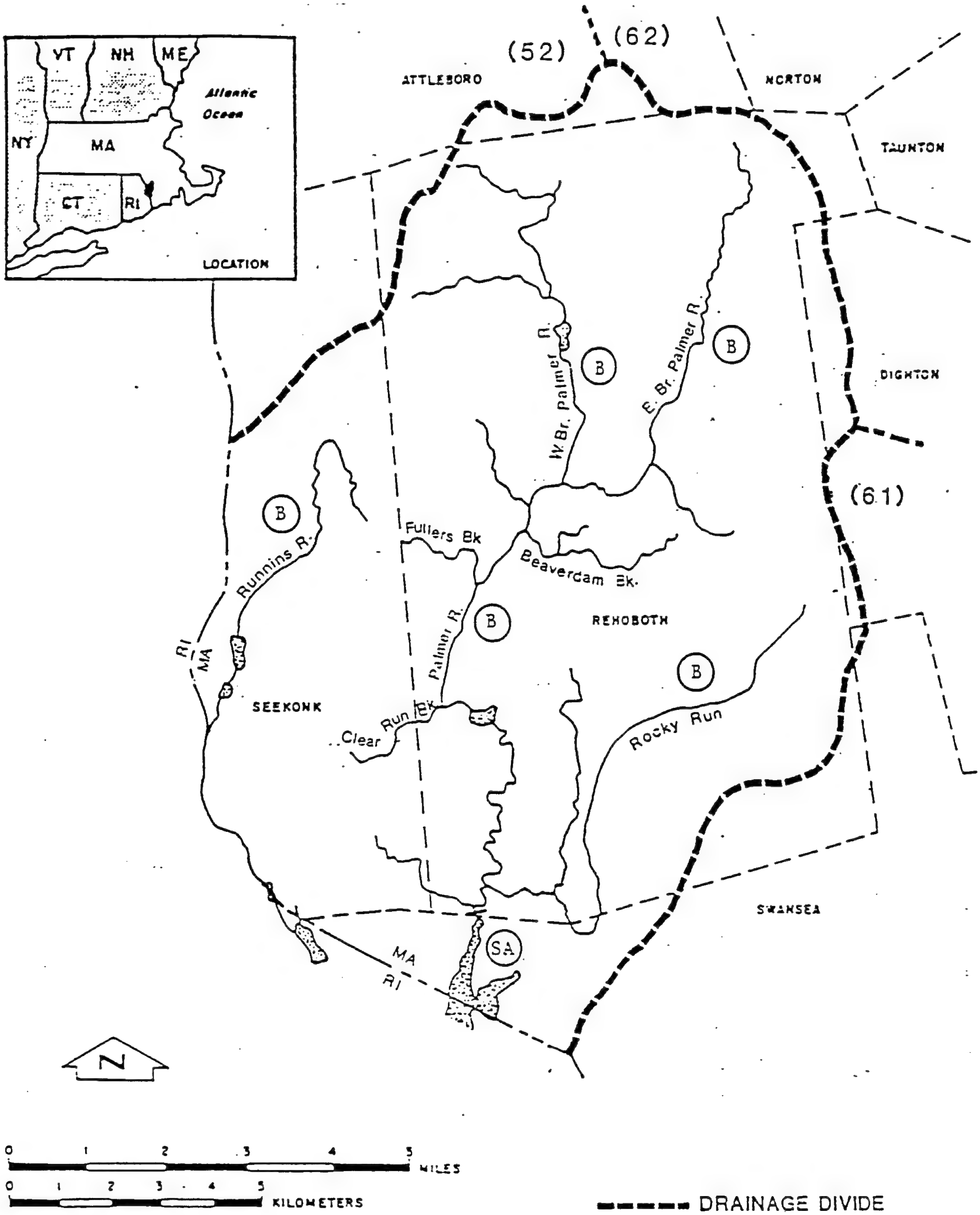
TIDAL FLOOD PROFILE NO. 6A

EAST SHORE OF NARRAGANSETT BAY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS
SEPTEMBER 1988

3

PLATE 6



SOURCE: MADEP-DPWC-TSS

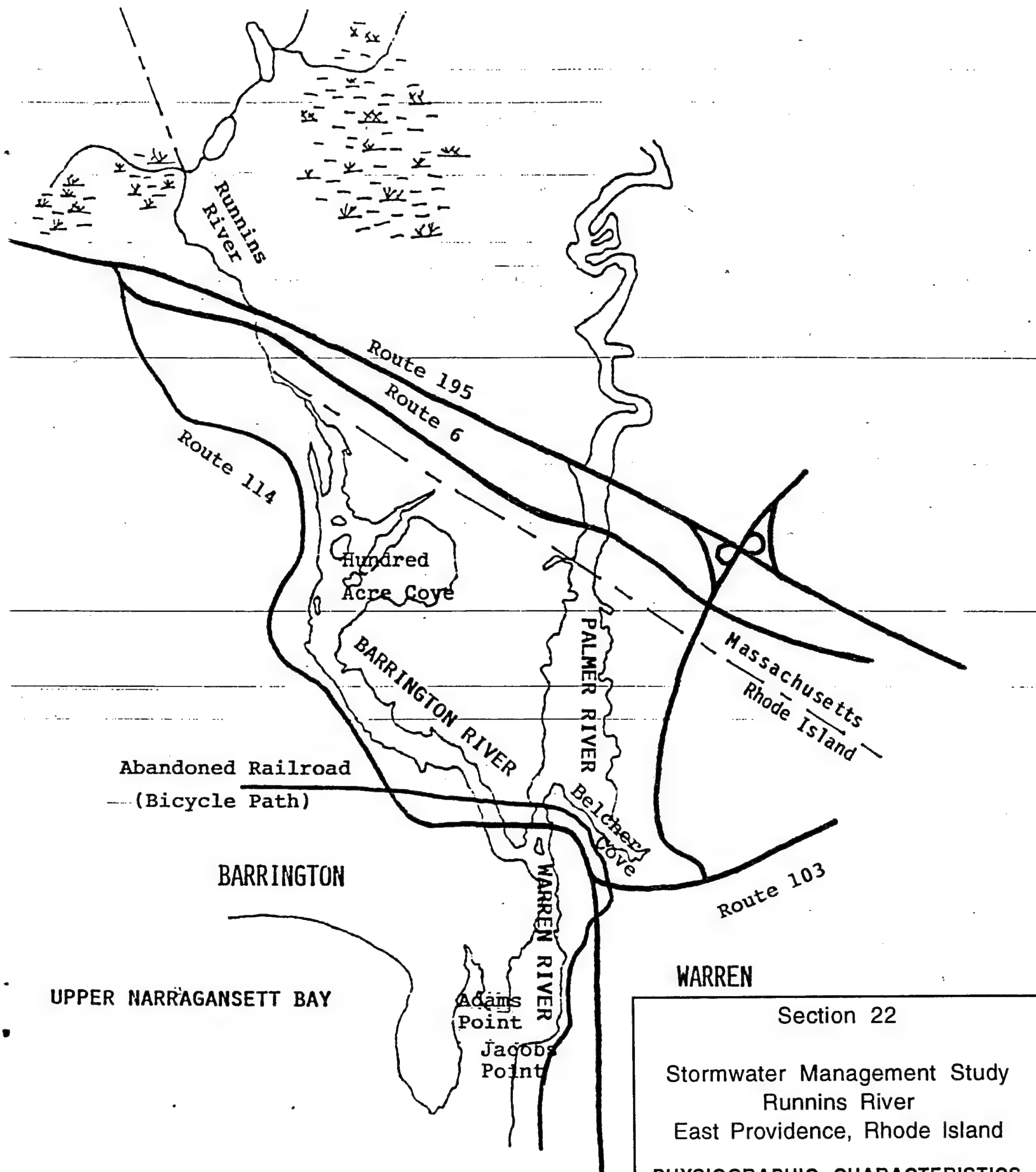
Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

NARRAGANSETT BAY DRAINAGE AREA, MASSACHUSETTS

E.E.H.B. PLATE 7 MARCH 1994

SOURCE: SHORELINE SURVEY REPORT, RIDEM, 1990



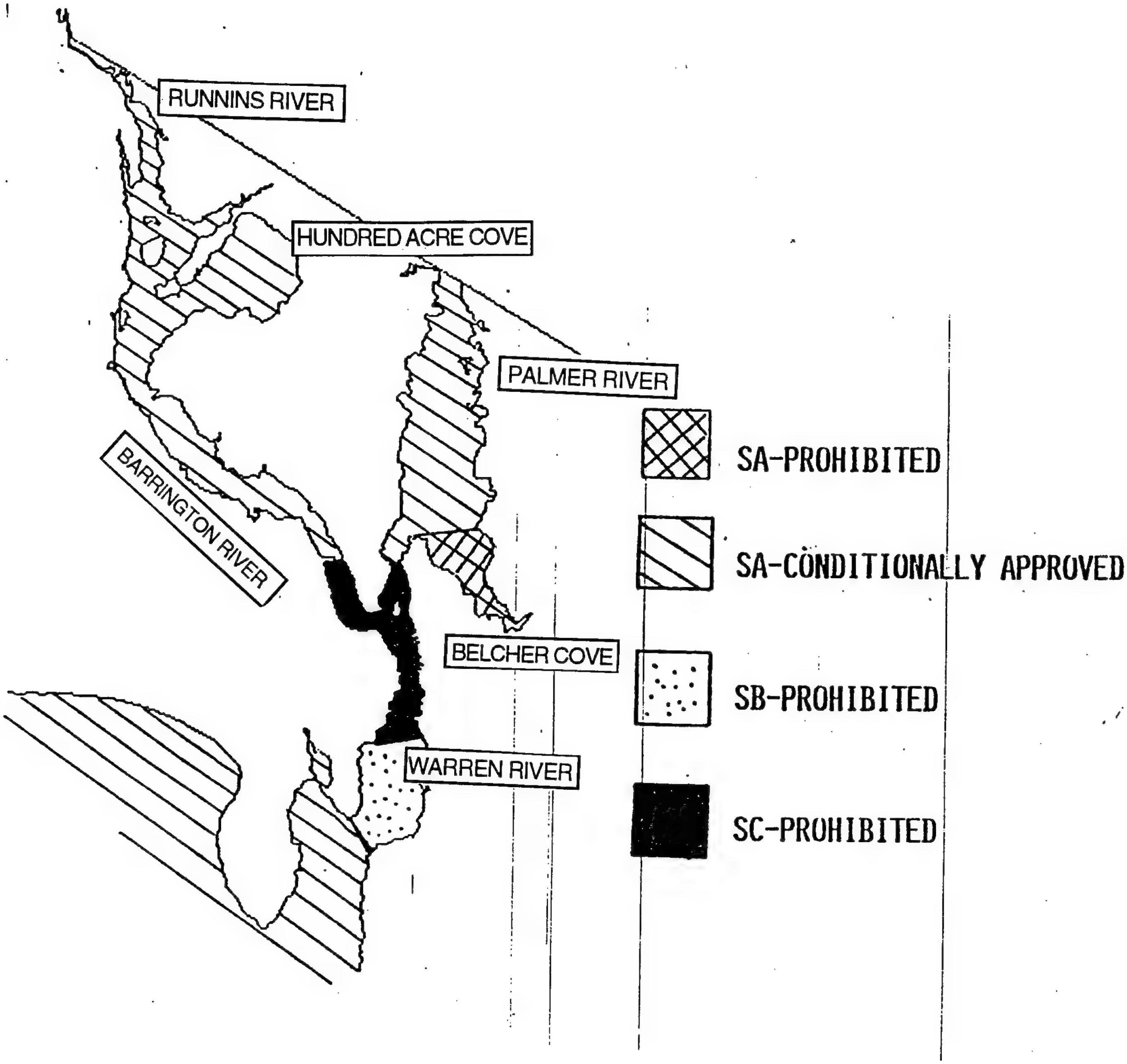
Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

PHYSIOGRAPHIC CHARACTERISTICS OF BARRINGTON, PALMER, AND WARREN RIVERS

E.E.H.B. PLATE 8 March 1994

SOURCE: SHORELINE SURVEY REPORT, RIDEM, 1990



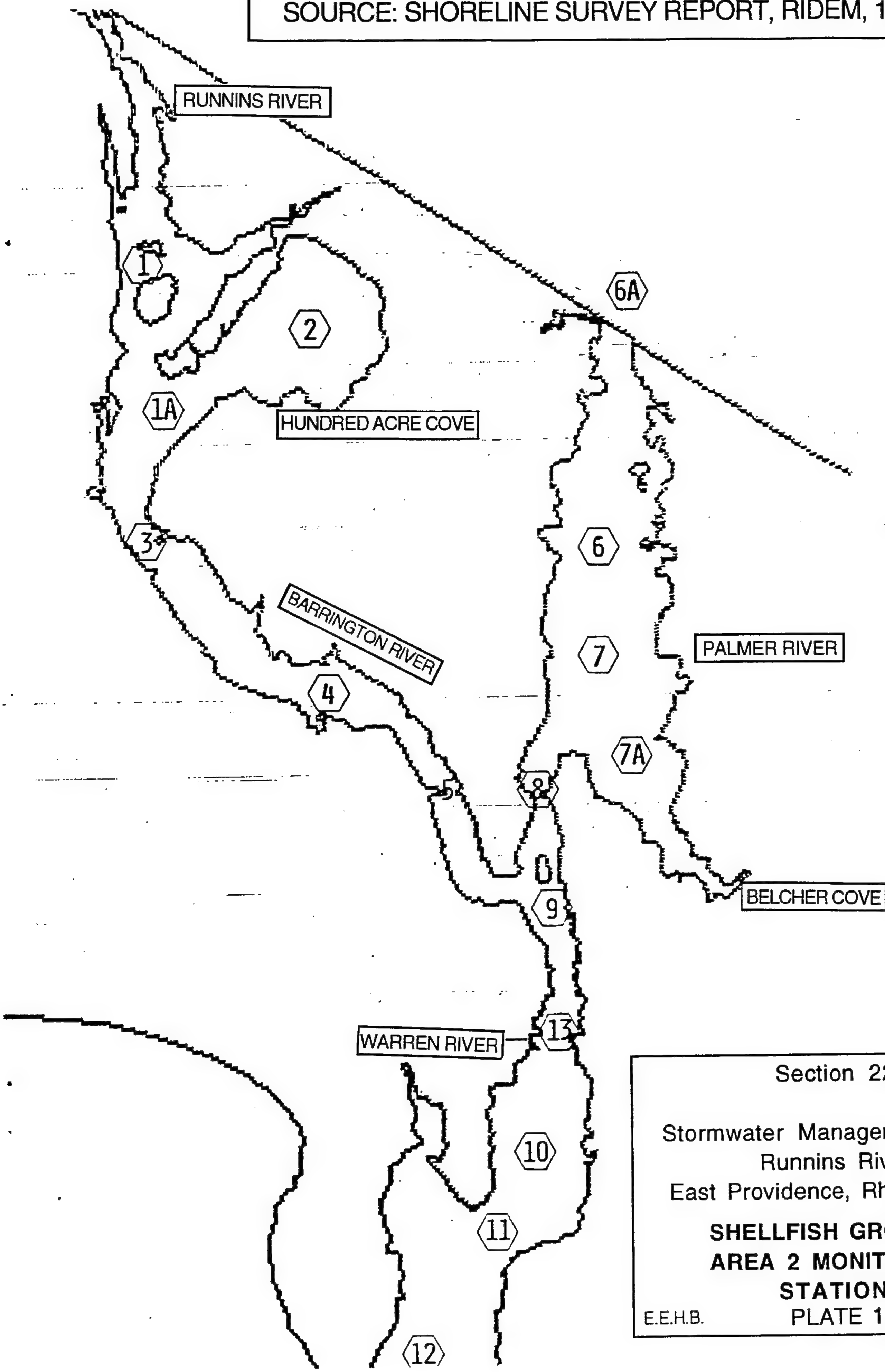
Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

STATUS OF SHELLFISH GROWING AREA 2

E.E.H.B. PLATE 9 March 1994

SOURCE: SHORELINE SURVEY REPORT, RIDEM, 1990



Section 22

Stormwater Management Study
Runnins River
East Providence, Rhode Island

SHELLFISH GROWING AREA 2 MONITORING STATIONS

E.E.H.B. PLATE 10 March 1994

SUB-BASIN BOUNDARY
James V Turner Reservoir
East Providence Center
Narragansett Race Track
Ledgemont Country Club
Seekonk Jr High Sch
Newman Ave Cem
Holy Ghost Cem
Newman Ave Sch
Seekonk High Sch
Central
PROVIDENCE CO.
BRISTOL CO.
Rumford
Thompson Sch
Wannamoisett Country Club
Phillipsdale
Omega Pond
TEN MILE RIVER
Golf Course
Radio Towers (WEAN)
Radio Tower (WHIM)
Mt St Marys Cemetery
East Providence Cem
Bucklin Point
Tidal Flat
Burns Sch
Wilson Sch
Jacobs Hill
Mt Carmel Ch
Substation
Townhall
Pleasant St Sch
PROSPECT STREET
WALNUT
DAVIS ST
READ ST
NEWMAN AVE
PIPELINE
HOPE ST
BLANDING
LAKE
ELM
CHESTNUT
TAUNTON AVE
NEWPORT AVE
PAWTUCKET AVE
GREENWOOD
BROADWAY
MANTON
MONTICELLO
BEVERAGE HILL AVE
METACOMET AVE
MASSASOIT AVE
DEWEY AVE
WOODWARD
Brook

DRAINAGE BOUNDARY
James V Turner Reservoir
East Providence Center
MASSACHUSETTS
RHODE ISLAND
Seekonk
Luthers Corners
Old Grist Mill Pond
Burrs Pond
Fifty Country Club
Pleasant St Sch
Seekonk High Sch
Newman Ave Sch
Townhall
Jacobs Hill
Mt Carmel Ch
TEN MILE RIVER
Golf Course
Omega Pond
Phillipsdale
Wannamoisett Country Club
Rumford
Thompson Sch
Hurst Sch
Upton Sch
Carpenters Corner
East Providence High Sch
Radio Towers (WEAN)
Radio Tower (WHIM)
Leonard Corner
EAST PROVIDENCE
Buckle Point
Tidal Flat
Central
PROVIDENCE
BRISTOL
PROSPECT
STREET
PIPELINE
HOPE ST
CHESTNUT
ELM
LAKE ST
ARCADE
TAUNTON AVE
BROADWAY
PAWTUCKET
CONRAIL
LINCOLN
BLANDING
MILLER
BRADLEY
HAMMOND
WOODWARD
NEWMAN
WEST
AVE

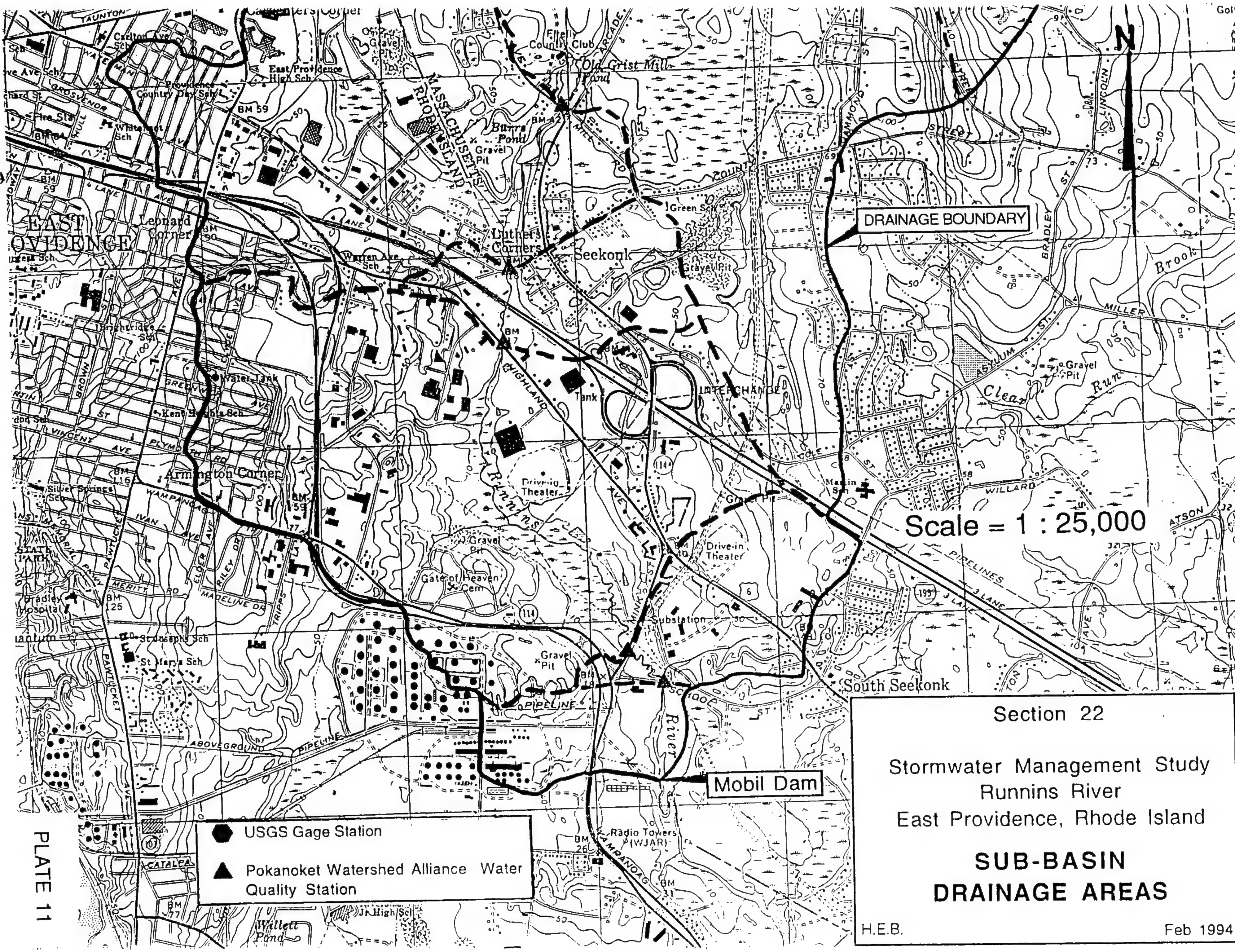

DRAINAGE BOUNDARY
Scale = 1 : 25,000
Mobil Dam
USGS Gage Station
Pokanoket Watershed Alliance Water Quality Station
Section 22
Stormwater Management Study
Runnins River
East Providence, Rhode Island
SUB-BASIN DRAINAGE AREAS
H.E.B.
Feb 1994
EAST PROVIDENCE
Seekonk
South Seekonk
Luthers Corners
Leonard Corner
Armington Corner
MASSACHUSETTS
RHODE ISLAND
Runnins
River
Clear Run
Brook
Old Grist Mill Pond
Drive-in Theater
Gate of Heaven Cem
Radio Towers (WJAR)
Willett Pond

PLATE 11

APPENDIX D

GLOSSARY

Aggregate - The stone or rock needed as fill for an infiltration device such as porous pavement, dry wells, or infiltration trenches.

Bankfull discharge - A flow condition where the stream channel is completely filled to the top of the bank.

Base Flow - Stream discharges derived from groundwater sources.

Best Management Practice (BMP) - A practice, activity, or procedure which has been determined to be the most effective means of preventing or reducing the amount of pollution generated by non-point sources. BMP's can be structural devices that temporarily store or treat urban stormwater runoff to reduce flooding and remove pollutants, or non-structural activities such as zoning and land use restrictions.

Biochemical Oxygen Demand (BOD) - The amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. A BOD test is frequently used to determine the pollution strength of wastewater (i.e., how much oxygen will be required for the pollutants to be broken down).

Buffer Strip or Zone - Areas of erosion resistant vegetation between a waterway and an area of more intensive land use.

Check dam - An earth or log structure used in swales to reduce water velocities, promote sediment deposition, and enhance infiltration.

Chemical Oxygen Demand (COD) - The measurement of the total quantity of oxygen required to oxidize organic pollutants to carbon dioxide in water.

Detention Basin - An impoundment for stormwater runoff usually consisting of a berm and outlet control structure. Detention basins temporarily store runoff and release it at a more appropriate time to prevent downstream flooding and erosion.

Drainage area - The area which drains into a watercourse at a given point.

Dry-weather flow - Flow in a storm sewer or drainage ditch which occurs in the absence of precipitation.

Dry wells - Similar to infiltration trenches, but usually smaller. Effective for reducing runoff volumes at sites less than one acre.

Eutrophication - The process of over-enrichment of water bodies as a result of excessive nutrients.

Evapotranspiration - The process in which plants take up water in their root systems and water evaporates from the plant surfaces.

Extended Detention Basin - Extended detention basins allow for removal of particulate pollutants. The outlet structure is raised above a predetermined surface elevation to detain runoff from a certain frequency storm.

First-flush - The initial portion of a rainfall event that appears as direct runoff and "washes" the surface of pollutants. This results in a small volume of runoff with very high concentrations of pollutants. The "first-flush" is sometimes characterized as the first half to one inch of runoff which can carry up to 90% of the pollutant load of the total runoff.

Forebay - A storage bay provided near an inlet of a BMP which traps sediment before it accumulates within the infiltration device.

Hydrograph - A graph for a given point in a stream or drainage area which shows the rate of discharge of stormwater runoff with respect to time.

Hydrologic Soil Group - A group of soils having the same runoff potential under similar rainfall and cover conditions.

Hydrology - The scientific study of occurrence and movement of water in the hydrologic cycle.

Illicit Connection/Discharge - Any connection/discharge to a municipal separate storm sewer that is not composed entirely of storm water, except those discharges pursuant to a National Discharge Elimination System (NPDES) permit.

Impervious Soil - A surface or geologic layer that does not allow appreciable movement of water or inhibits infiltration or percolation.

Infiltration - The downward movement of water from the surface into the soil profile. (inches per hour) Infiltration consists of rainfall minus interception, evaporation, and surface runoff.

Infiltration Basin/Trench - A "best management practice" utilizing the infiltration capacities of the soil. They are effective at removing both soluble and particulate pollutants from urban runoff.

Inflow - Water which enters a sanitary sewer system from surface locations such as manhole covers.

Interception - Precipitation retained on vegetative surfaces and either absorbed, evaporated, or sublimated.

Level-spreader - A device used to spread out stormwater runoff uniformly as sheet flow. This is to prevent concentrated, erosive flows from occurring, and to enhance infiltration.

Loam - Soil material that is 7 to 27% clay, 28 to 50% silt, and less than 52% sand.

Municipal Separate Storm Sewer - Conveyance or system of conveyances, including public roads with drainage systems, that is owned or operated by a city, town, county, district, etc., that discharges to waters of the United States and that is designed solely for collecting and conveying storm water.

National Pollutant Discharge Elimination System (NPDES) - The national program for controlling discharges from point source discharges directly into waters of the United States under the Clean Water Act.

National Urban Runoff Program (NURP) - A research and development program conducted between 1978 and 1983 that characterized the composition of urban runoff and potential solutions and control techniques.

Non-point source pollution - Pollution in surface or ground waters not attributable to known discharges or point sources.

Nutrients - Elements or substances, such as nitrogen and phosphorous, that are necessary for plant growth.

Outfall - The point where a municipal separate storm sewer discharges to a receiving water

pH - A commonly used parameter to measure acidity.

Peak discharge - The maximum instantaneous rate of flow during a rainfall event.

Percolation - Gravity induced flow of water through the pores or spaces of a soil or geologic layer.

Point source pollution - Water pollution resulting from a discernible or confined conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, etc.

Porous pavement - Pavement with a high void aggregate base that allows rapid infiltration of stormwater runoff.

Receiving water - Natural or man-made watercourse in which stormwater or wastewater is discharged.

Retention Basin/Wet Pond - An infiltration BMP which stores runoff and allows it to infiltrate into the soil profile. This structure usually retains a permanent pool of water between storm events.

Runoff - Rainfall which does not infiltrate the surface of the soil and percolate through the soil profile, thus leaving a site as overland flow.

Sedimentation Basin - A pond or basin at the upper end of a stormwater control facility to capture and store sediment.

Septic system - Typically used in areas not containing public wastewater conveyance systems. They include a septic tank to permit settling of solids and flotation of grease and fats, and a leaching field to distribute effluent into the soil column.

Sheet flow - Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

Stormwater - Water runoff from precipitation, snow melt, surface runoff, and drainage.

Stormwater Discharge Associated with Industrial Activities - Stormwater discharge from any conveyance which is used for collecting and conveying stormwater and which is directly related to manufacturing, processing, or raw material storage areas at an industrial plant. This includes, but is not limited to, industrial plant yards, immediate access roads and rail lines used by carriers of raw materials, manufactured products, waste materials, shipping and receiving areas, and raw material storage areas. This also includes construction activities which disturb five or more acres of total land area.

Subwatershed - Tributary watershed within a larger watershed.

Surface storage - Precipitation that ponds in surface depressions.

Surfactants - Surface-active agents and common components in detergents which affect the surface tension of water and can cause foaming.

Swale - A BMP infiltration device designed as a wide shallow ditch used to temporarily store, route, or filter runoff.

Time of concentration - The time required for runoff from the most hydraulically distant point of a drainage area to reach the outlet.

Total solids - The entire quantity of solids in a liquid including the dissolved and particulate fractions.

Turbidity - A measure of the lack of clarity of water usually caused by suspended particulate matter.

Urban runoff - Stormwater runoff from an urban drainage area characterized by typical commercial, industrial, and residential land uses.

Vegetated Filter/Buffer Strip - Filter/Buffer strips are similar to swales, but are designed only to accept runoff in the form of sheet flow.

Watershed - The catchment area for rainfall which is delineated as the drainage area producing runoff.

Wet-weather flow - Any flow resulting from precipitation which may introduce contaminants into a storm drainage system.

APPENDIX E

SCOPE OF SERVICES

Runnins River Watershed
Stormwater Management Study

Scope of Services

I. Introduction:

a. Authority:

The Corps of Engineers was requested by the Rhode Island Department of Administration, Division of Planning to conduct a stormwater management study of the Runnins River watershed in East Providence, Rhode Island under the authority contained in the Section 22, Planning Assistance to States Program. The City of East Providence is the cost sharing partner for this investigation which will be coordinated through their Department of Planning and Urban Development.

b. Study Purpose and Scope:

The purpose of this investigation is to define the Runnins River watershed and evaluate and document the quantity and quality of stormwater surface runoff into the river through watershed modeling of hydraulic conditions. In addition, the following tasks will be accomplished: analysis and review of existing water quality data; possible limited water quality sampling; analysis and inventory of existing development and land use contributing to the water quality degradation; and, identify possible solutions to be implemented such as best management practices, regulatory and institutional controls, and source controls. The framework for a comprehensive stormwater management strategy will also be developed for the watershed. A stormwater management strategy would provide for the protection and enhancement of water quality and wildlife habitat within the watershed.

The study will be coordinated with all appropriate Federal, State, Municipal and other interested parties.

The scope of this study will be limited to existing information and ongoing data collection efforts available from Federal, State, Municipal and other sources. Ongoing data collection efforts include, but are not limited to, wet weather water quality sampling scheduled to be accomplished by the New England Interstate Water Pollution Control Commission and, water quality sampling by the Pokanoket Watershed Alliance. It is expected that this information

will be utilized as part of this study effort. This study will focus on identifying problems and formulating solutionsfor the portion of the watershed within the City of East Providence. Areas of additional study will also be identified.

c. <u>Data Provided by City of East Providence:</u>

The City of East Providence has agreed to supply existing land use data, zoning data, and other pertinent information to aid in the development and documentation of the quantity and quality of stormwater surface runoff into the river.

II. Project Tasks

a. <u>Define Watershed Boundaries & Characteristics & Develop Hydrologic Watershed Model:</u>

Delineate watershed and subwatershed boundaries for the entire Runnins River. Identify and describe the physical characteristics of the watershed and identify the location of storm drain discharges into the river.

Develop a hydrologic model of the Runnins River watershed using the Corps' computer program HEC-1. Determine storm runoff rates and volumes for various frequency storm events. Determine possible impacts to flood flows of increased development throughout the watershed.

b. <u>Water Quality Analysis & Sampling:</u>

Review of standards and past and present condition of water quality in the river based on available studies, information, and data from Federal, State, Municipal, and other sources. Assess overall existing water quality based on existing data. Discuss possible future trends in water quality, further sampling needs, and actions which can be taken to improve water quality.

Various grab samples to supplement existing data may be taken. Representative parameters may include, but not be limited to: coliform, BOD, and metals such as lead and mercury.

c. <u>Identify Possible Solutions & Develop Recommendations:</u>

Based on the results of the modeling process and other information gathered during the study, various solutions will be identified, described, and recommended. The framework for a comprehensive stormwater management plan will also be developed for the watershed. Possible solutions will likely include the use of Best Management Practices (BMP's), regulatory and institutional controls, and source controls which emphasize the prevention and/or reduction of non-point source pollution within the watershed.